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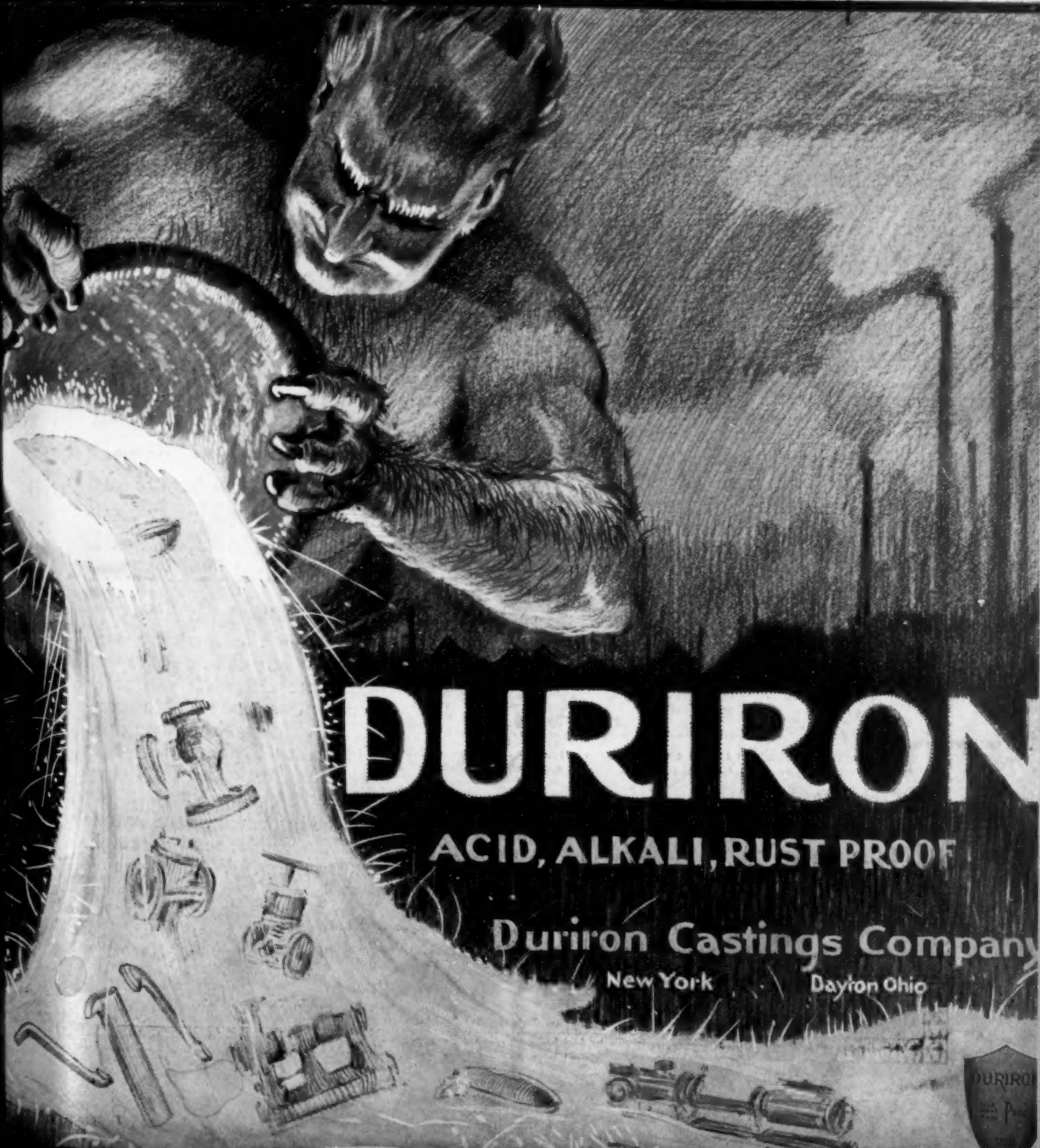

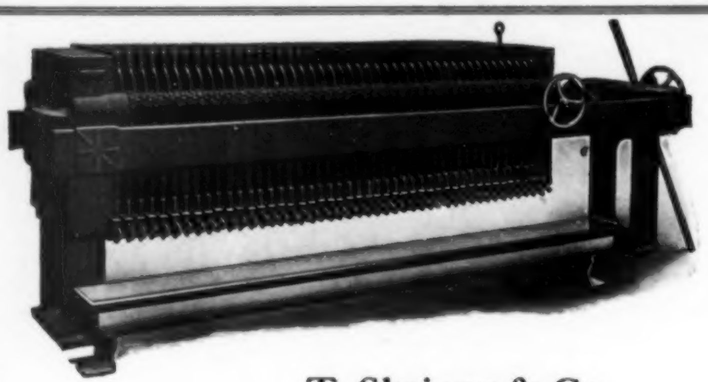

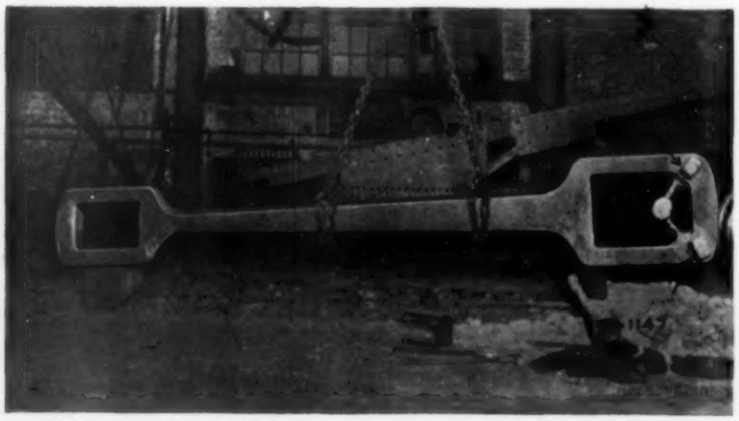

Two Thermit welds made in one operation on a connecting rod for a 34-in., 6000 H.P. reversible slab mill engine. Section at welds 7½"x6".

Metallurgical and Chemical Engineering

A Consolidation of
ELECTROCHEMICAL AND METALLURGICAL INDUSTRY and IRON AND STEEL MAGAZINE

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Contents for November 1, 1915

Artificial Indigo Made in the United States

The announcement on page 776 of this issue to the effect that the Dow Chemical Company of Midland, Mich., is erecting an artificial indigo plant of a daily capacity of 5000 lb. of 20 per cent indigo paste, will be welcome news to all who, at the recent Exposition of Chemical Industries in New York City, looked at the first sample of artificial indigo made by this company. Mr. H. H. Dow has been an enterprising and courageous pioneer of industrial chemistry in America in many ways. His electrolytic work on a large scale has been of considerable originality and very successful. In transplanting the manufacture of artificial indigo—one of the greatest triumphs of German chemistry—to American soil, Mr. Dow is setting a new milestone in the development of the American dyestuff industry and deserves the heartiest good wishes for the success of his enterprise and pluck.

It still takes a very plucky man to erect a new dyestuff plant in this country. This will be evident from the report on page 779 of the meeting held last week on the dyestuff situation by the New York Section of the Society of Chemical Industry. It was a lively and enthusiastic meeting and there was unanimity of opinion that this country should and must have a dyestuff industry able to fill the needs of the country. But there was anything but unanimity of opinion as to the best way to go about it. Free expression of contrary opinions is always beneficial; and contrary opinions of all shades were expressed from the socialistic demand for a Government factory for the production of the intermediates as one extreme to the individualistic laissez-faire doctrine on the other hand that "the dumping clause is all nonsense; the textile man has a right to buy at the lowest price; everything else is theory and bunk."

This country has two prerequisite elements for the success of a large dyestuff industry—the raw materials and the market. Further a sufficient supply of chemists and chemical engineers—the intellectual raw materials of the industry—will be available in time and in time the technical skill will be acquired which comes only from long years of practice. But it would be foolish to overlook that this will take years of hard work, especially as the dyestuff industry does not lend itself to mass production. During this period of evolution the growing American dyestuff industry will need protection by the government. On this everybody in the meeting last week agreed. But while the whole chemical industry is unanimous in its conviction of the absolute necessity of a protective *tariff*, besides an anti-dumping clause, the representatives of the government shirked *tariff* discussion. Dr. E. E. Pratt, in his other-

wise excellent and very able address, thought that the tariff question is of less importance and can be left out of the discussion, as "we are not likely to reach any final conclusion in such a discussion." This may have been politically expedient, but to us it was the most disappointing note in the whole evening's discussion. Will even those government officials who are most intimately connected with the chemical industry, overlook the obvious fact to which we emphatically called attention at this place last week, namely, that the American chemical industries face a condition, not a theory, and that the abstract question of the desirability or undesirability of protective tariffs has nothing to do with the special concrete situation with which the chemical industry of this country and all who depend on it are now confronted?

Electrolytic Zinc

The production of electrolytic zinc is engaging the serious attention of an increasing number of leading metallurgical concerns, with a fair prospect of developing methods that will practically solve some unusual problems in ore treatment. This impetus to zinc hydrometallurgy with electrolytic recovery arises mainly from the necessity of devising wholly new or improved methods of treating silver-bearing zinc ores and certain complex zinc sulphide ores which are not amenable to ore dressing. Further, the prospect of high prices for spelter makes the present a peculiarly favorable time to embark in new enterprises of this sort.

At Trail, B. C., the Consolidated company is investigating the production of electrolytic zinc from a zinc-lead ore which contains the sulphides of those metals intimately associated in finely crystalline form. Mechanical methods of separation and enrichment are not applicable, and chemical means must be employed. At Anaconda an experimental plant for electrolytic zinc is in operation on certain silver-bearing Montana zinc ores. Near Salt Lake City and San Francisco further work is under way with electrolytic zinc as the goal, and encouraging experimental results are reported.

If the outcome at any one of these places gives the solution of a special problem in zinc metallurgy, a useful and economic purpose will have been served, and the way may be paved to an extension of the process. As has frequently been observed, it is unlikely that the present art of zinc smelting will be revolutionized by these special processes, but there is always the prospect that changing economic conditions will make it possible to widen a field which at first appeared narrow. Prophecy is always hazardous, but particularly so when it attempts to forecast what cannot and never will be accomplished. Electrolytic zinc may still become a case in point.

Bessemer Steel

The place that Bessemer steel now occupies in the steel-consuming industries is one that has been made by fortuitous circumstances rather than by design, and the place is not as important as it might be. This is unfortunate now, for a famine is threatened in steel, and the famine would be reduced in intensity if Bessemer steel were more generally used. The metallurgist has confined himself almost exclusively to open-hearth steel, his effort being to improve open-hearth steel rather than Bessemer. He might have done differently if he had not been restricted in the matter of phosphorus. There is, and has been for many years in the United States, practically but one phosphorus content, and that is a content that will just pass muster as being not over 0.10 per cent. It is curious in the retrospect to reflect that the influence that caused the rapid erection of basic open-hearth furnaces in recent years was the same influence that caused the phosphorus to be fixed at as close to 0.10 per cent as possible, that influence being fear of a shortage of Bessemer ores. The metallurgists have not been allowed to consider what might be done with a Bessemer steel of 0.06 or 0.08 phosphorus content. There are ores that will make such steel, but established custom is to mix them with ores of higher phosphorus content, so as to produce a steel just within the established limit. The custom has been established for years, but it is justifiable at this time to raise a question whether it has not outlived its usefulness.

The distinctively bad feature of commercial Bessemer steel is its low shock ductility in proportion to its static ductility, a characteristic usually attributed to its phosphorus content. This difference between static and shock ductility, established by the engineers, has become generally recognized in the commercial use of steel, whether or not the users themselves know the meaning of the terms static and shock ductility, for one finds the widest use of Bessemer steel to-day in the manufacture of wire, tin plate and steel pipe, all commodities which are relatively little subject to shock in actual use.

Apart from modifications that might be made in the composition of Bessemer steel by a less rigid conservation of the relatively low phosphorus ores, a more widespread use of Bessemer steel might perhaps be cultivated by a judicious educational campaign. For instance, phosphorus tends to produce coarse crystallization, and the temperature to which the steel should be heated in rolling is correspondingly limited. Black plate for tinning is rolled in packs, and to prevent scaling of the tin plate bar and sticking in the pack, which would result in surface imperfections, the rolling is conducted at a lower temperature than any other hot rolling operation. It is a fortuitous circumstance that the practice conduces to bringing out the best physical qualities of Bessemer steel, yet it will hardly be denied that it does do so, and more attention paid to rolling temperatures in other classes of mills might result in a distinct gain.

There has been little disposition in the steel-making trade to encourage the use of Bessemer steel because commercial conditions have not favored the effort. When the demand for steel is small, the producers who can furnish either open-hearth or Bessemer gladly furnish the former, for as a rule they can make it somewhat more cheaply, and every cent per ton counts in such times. When the demand for steel is excessive the buyer is expected simply to take what he can get, to select rela-

tively prompt delivery of Bessemer steel in preference to later delivery of open-hearth steel, if the earlier delivery will suit his purpose better. Thus the position of Bessemer steel, while apparently open to criticism from the technical standpoint, is regarded as defensible from the commercial standpoint.

Riffling Concentration Tables

The present method of riffling concentration tables has not varied greatly from that which was early adopted and found practicable. Such changes as have been made have been conservative, and until recently practice seemed to have become standardized, with little thought of departure from existing custom. We may draw two inferences—either we have reached the ultimate in riffling, or else standardization has acted as a bar to progress by creating the impression that there is nothing to be gained by leaving the beaten trail.

Generally speaking, it seems probable that standardization has been more complete and has been accepted with less question in the case of riffling than in other factors in ore treatment. The same type of riffling has been used with a great variety of ores and under widely different conditions. In this respect we have acted at variance with an accepted principle; viz., that each ore presents an individual problem requiring special study to provide the most efficient method of treatment. Have we given sufficient study to the development of special forms of riffling for different ores, to the end that the best results in concentration may be secured? We think not. As a rule the standard forms of riffling have been adopted without question and often without experiment, while considerable study has been given to other features of the process to be employed.

Considering the diverse conditions existing in concentratable ores, a study of the effect of variations in riffling seems to offer a fruitful field for investigation. One who has engaged in this line of research has obtained results that are surprising, leading to the broad conclusion that, for a given ore, experiment may reveal a method of riffling that will prove more effective than the standard forms. In a number of cases wherein ordinary types of riffling have been ineffective, the results have been remarkably improved by varying the depth, spacing or arrangement of the cleats on the deck. The point seems worthy of more attention than it has received in ore testing.

A "Steel Famine" Possible

The pressure upon the steel mills for steel has reached a tense stage. Buyers are clamoring to place orders and contracts, while the mills are unprecedently reserved in the making of commitments. In October, 1912, when the buying movement of that year reached its height, the increase in the United States Steel Corporation's unfilled obligations was more than a million tons. No such monthly increases are permitted now.

The insistence of the demand for steel is proved quite conclusively by a comparison of the course of prices in this movement and the course in the last movement. In the past decade there have been three major movements in the steel market, that of 1905-6-7, that of 1909 and that of 1912. Steel prices have advanced steadily from the beginning of the year to the present time. The low point of last December was a shade below the low point that preceded the 1912 rise. Present prices for finished steel products are now at an average level with the top prices reached in the 1912 movement, and they are now advancing at a more rapid rate than at any previous time in this movement, a conclusive evidence that the movement is a much stronger one than its predecessor.

To what extent the production of steel can be increased is problematical. The pressure is distinctly upon the steel-producing units, not upon the blast furnaces nor upon steel-rolling departments. To increase the production of steel it would not be necessary to build from the ore mine to the finished product. The relation between steel-producing capacity and blast furnace and steel-rolling capacity, however, is an abnormal one, because an important proportion of the present steel output is of shell steel, involving a heavy discard from the ingot, and thus the proportion of steel rolled to steel poured is abnormally low, and this low proportion is to be simply concurrent with the duration of the war. A not unimportant fact is that the production of steel in the next three months may be less than in the past three months, on account of unfavorable weather conditions.

The United States has about 45 per cent of the pig iron making capacity of the world, and approximately the same proportion of the steel-making capacity. Six months ago the proportion would probably have been estimated at nearer 40 per cent, but the performance of American blast furnaces in the past few months, many of them, if not the majority, breaking all their previous records, though with no change in the physical equipment, indicates that the total capacity of the United States is two or three million tons a year greater than was estimated before this recent test.

All the other iron-producing countries of the least importance are engaged in the war. As a group their exports of iron and steel to non-producing countries are very greatly reduced, and the non-producing countries, recovered in some part at least from the financial shock produced at the outbreak of the war, and with the stocks of material they were carrying greatly reduced if not entirely exhausted, are calling for much more material from the United States. The entente allies, although as a group large producers of iron and steel, are calling upon the United States for enormous tonnages of material in various stages of manufacture.

Business in the United States has been rapidly reviving, with further expansion promised. Productive capacity in the iron and steel industry has grown much less rapidly since 1909, when the great construction program the industry had assumed in 1906 and 1907 was finished, than it did in earlier years, and altogether it is not surprising that a famine in steel should now be threatened.

American Indigo Industry

The Dow Chemical Company of Midland, Mich., is erecting an artificial indigo plant with a capacity of producing 5000 lbs of ordinary indigo paste daily.

As mentioned in our report of the First National Exposition of Chemical Industries, held in New York City in September, a sample of artificial indigo was then exhibited. It may now be stated that this had been produced by the Dow Chemical Company which had a miniature factory for the production of indigo in successful operation for several months.

It is interesting to note in this connection that there are 39 research chemists on the staff of the Dow Chemical Company. They are working in nine different laboratories.

Niagara Falls Section American Electrochemical Society

Transformers for Electric Furnace Work

(*From Our Special Correspondent*)

An air of unnatural solemnity overhung the meeting of the Niagara Falls Section of the A. E. S. at the Niagara Falls Power Co. on Oct. 12. Whether this was due to the fact that some of the liveliest members were engaged elsewhere in electioneering; whether to the whispered tones employed by most of the speakers, apparently awed by the solemnity of a "first meeting"; whether to the fact that the president had secured more material than he could comfortably work off in a reasonable time and consequently was unable to employ his favorite tactics of stirring things up, the fact remains that there were no casualties.

L. E. Imlay opened the proceedings by directing the attention of the audience to the useful subject of reactance in transformers, external and internal, and described, with diagrams, its effect in protection and its effect on regulation. W. S. Horry, who followed, refused to be bound by any narrow regard for the subject of the evening; he preferred to warn the section of the importance of starting its life with a proper conception of its duties and its limits; "from the Niagara River to the secondary we meet on common ground," he stated, and broadly hinted that beyond the secondary were mysteries into which it would be, to say the least, tactless to inquire. After defining a transformer as something which was bound to be frightfully overloaded in the course of its life, he stated that he did not see that anything more could be asked than that shop tests should show that specifications had been complied with, though, he added, as an afterthought, that provision against breakdowns was, of course, paramount. That this paramount condition is not always fulfilled was the burden of the next three speakers, who told harrowing stories of their experiences in recent years. These pictures were, however, not without lighter relief, as when F. J. Tone celebrated Columbus Day by describing how Paul Lincoln and F. A. J. FitzGerald discovered power factor in the early days of the Carborundum company. A. M. Williamson gave a psychological study of the effect on an operating superintendent of the information that "number one unit is on the bum and due for a ride on the flat car," but paid a tribute to the increased efficiency of the repair department of the transformer company by contrasting the 175 days necessary for the repair of the first unit with the most recent record of forty-five on the fourth; the curve was apparently logarithmic, and indicated an approach to 100 per cent efficiency in 1926. F. A. Lidbury sighed for the old days of 2200-volt primary operation, and described some highly unconventional surgery performed on an old transformer built in 1897, for which he evidently had a great affection. F. A. J. FitzGerald described some experiments made by simultaneously observing the temperature of oil in transformers and the temperature of the coils themselves by the "thermoscope," and drew the conclusion "that transformers which are apt to be overheated should be supplied with devices that will let the operators know when the coils are at a dangerous temperature instead of the thermometer in the oil, for this is worse than useless, giving as it does a false sense of security."

Mr. McConahey of Pittsburgh followed with an interesting description of problems in transformer design and manufacture, and showed a large number of lantern slides chiefly illustrating methods of bracing. He prefaced this exhibition by the remark that he was going to let us into a few transformer secrets, that "we electrical engineers are not like you electrochemical men—we don't keep everything we know under our hats." After this wild horses could not drag from us what he said.

John J. Frank of Pittsfield followed, and he really tried to start something. "When you are in trouble, call upon someone who may know more about it than you do," he began, and left little doubt in the minds of his audience whom he meant; after this, however, we were scarcely prepared for his admission that "twenty years ago we didn't know as much about transformers as we do to-day." Acting upon the Billy Sunday principle, that the easiest way to become popular with your audience is to abuse them, he proceeded to draw up a frightful indictment of electric furnace men. According to the speaker, they habitually overloaded transformers 500 per cent; and "when a piece of apparatus is rated 1000 kw. and you take 5000 out of it for years something must happen." Worse still, short-circuiting transformers was one of their favorite amusements, and they were further guilty of hiding from the innocent transformer manufacturer all manner of frightful conditions, high frequencies, rectification phenomena, and so on. Of course, this roused the president's ire at once, as it was intended to do, and there might have developed a certain liveliness had not Mr. Greene, also of Pittsfield, who followed, thrown oil on the troubled waters by admitting that transformer designers owed much of what they to-day know to the co-operation of users of transformers, and particularly to electric furnace men. According to Mr. Greene, the manufacturer now knows how to build to withstand short-circuit and voltage stresses, and on this assumption the most important question is now that of voltage regulation. The induction regulator, while most satisfactory, is too costly, therefore control by taps and dial switches, with intermediate arrangements where necessary, is now being resorted to. He outlined the tendencies in construction along these lines at the present day.

After some discussion as to the respective merits of internal and external reactance, and the amount of reactance for various conditions, in which F. J. Marshall, A. J. Jones, R. H. White and C. A. Winder participated, the meeting adjourned.

The Iron and Steel Market

Steel buyers have become much more insistent in the past fortnight, while steel producers have become still more reserved in the matter of making contracts for forward delivery, resulting in a tense situation, with prices tending to advance more rapidly than at any previous time in this upward movement, now ten months old. Effective Oct. 25, the Carnegie Steel Company advanced bars, plates and shapes $1 a ton, to 1.50c.,

this price at once becoming the minimum of the market. The company's previous advance was dated only ten days earlier, while the preceding advance had been about a fortnight earlier, making a total advance in these products of $3 a ton in less than thirty days. With their related products of skelp, hoops, bands, etc., these products comprise fully one-half the total rolled-steel product of the industry, excluding standard rails, which may properly be excluded in such a comparison as they have not changed definitely in price in more than fourteen years.

The average price of all finished steel products is now equal to the average in the winter of 1912-13, when the great advance of 1912 had culminated and the market was preparing for a period of decline. Prices are still about $2 a ton below the highest level reached in the 1909 rise, and about $6 a ton below the level of 1907. It would be quite unsafe to venture a prediction that the records of 1909 and 1907 would not be broken even in a very few months, so strong is the present price advancing tendency.

The physical influences in the steel market are very strong. Mills have been falling farther and farther behind in deliveries, although in the past three months they have not only produced steel at a much greater rate than ever before, but have doubtless attained the maximum output of which they are capable. Consumptive demand by domestic industries generally is increasing, while the railroads are facing a car shortage not merely during the crop-moving season but thereafter, while their net earnings are at a new high record. The demand from certain belligerent countries is extremely heavy, with no signs of abatement, and the demand from neutral countries is constantly increasing.

The mental influences in the steel market are equally strong, in the matter of tending to advance prices. Buyers of steel are familiar with the fact that war tends to raise prices and recognize that the demand for steel is unprecedented, so that they are much less disposed to resist advances than is usually the case. Sellers are distinctly governed by a different policy than formerly. The theory that steady prices for steel mean steady demand has not worked out satisfactorily. Having passed through a long and severe depression, steel producers are committed to a policy of securing returns when returns can be secured, and the demand with which they are confronted is in the main not such as would be curtailed by price advances to the extent that might be expected under normal conditions. It is a patent fact that conditions in the world are very far from normal.

Thus both physical and mental influences combine to give a strongly advancing trend to steel prices. The end is by no means in sight, and it is easy to imagine prices advancing much more in the next ten months, possibly in the next six months, than they have advanced in the past ten.

Connellsville Coke

An outstanding feature of the general course of prices in the iron and steel industry during the first nine months of the year was that Connellsville coke failed to score any material advance, whereas in previous price movement in the industry coke advanced much more in percentage than did pig iron or steel. The reason was that the rapid erection of by-product coke ovens in recent years produced a total coke-making capacity much in excess of the possible requirements of blast furnaces. Late in September, however, the strength in the general situation became so great that furnaces began to inquire for coke for 1916 delivery, against the expiration of contracts at the close of this year, and in succeeding weeks, up to the middle of October, the major portion of the contract business was done at prices averaging about $2.25 per net ton at ovens, an advance of perhaps 50 cents a ton over contract prices for the present half-year. Furnace coke for prompt shipment remained at a relatively low price. The middle of October found prompt furnace coke at $1.75 to $1.85, and then prices jumped suddenly until within a few days as high as $2.75 was paid for coke for spot shipment. The production of the Connellsville region expanded until a point was reached at which labor scarcity intervened. It remains a question whether the scarcity of coke for prompt shipment will be relieved, or the contract price for next year will advance to the level of the prompt market.

Pig Iron

After the fairly sharp advances that characterized the pig-iron market in July, August and September, a distinct lull occurred in buying, and prices were stationary for practically the first three weeks in October, when a fresh advancing movement began, based not so much upon an increase in buying as upon sentiment, as steel prices were rising rapidly and a broader market for pig iron seemed in prospect. In the past fortnight Southern iron has advanced 50 cents a ton, while the Chicago furnaces marked up prices by no less than $1.50 and foundry iron in the valleys advanced 50 cents, to a level with the previously established market for basic iron, a level to which it was entitled by reference to cost of production. The steel mills do not buy merchant pig iron to the extent usually expected when they are crowding for production, but predictions are made that consumption by iron foundries is destined to increase materially. The market is quotable as follows: No. 2 foundry, delivered Philadelphia, $16.25 to $16.75; f.o.b. furnace, Buffalo, $15.50 to $16; delivered Cleveland, $15.25; f.o.b. furnace, Chicago, $15.50 to $16; f.o.b. Birmingham, $12 for prompt and $13 for first half delivery; at valley furnaces, 95 cents higher delivered Pittsburgh: Bessemer, $16; basic, malleable and foundry, $15; gray forge, $14.50.

The Jones & Laughlin Steel Company has leased Rebecca, a merchant stack at Kittanning, Pa., and will manufacture its ferromanganese at that furnace, thus releasing one of the stacks at its Aliquippa works for the production of standard basic. Rebecca was idle, but plans had been completed by the owners for blowing it in on basic iron for the market.

Steel

Soft steel billets have not been really a market commodity of late. The mills were oversold for early deliveries and did not care to make commitments for late delivery. Nominally the market has been called $25 for Bessemer and $26 for open-hearth billets, with $1 extra for sheet bars, but practically there have been no sellers. Transactions for 1916 delivery are just beginning. A sale of 4500 tons of open-hearth sheet bars for delivery January to June has been made at slightly over $30 delivered, equivalent to about $28 at maker's mill, Pittsburgh, and Bessemer sheet bars are reported to have been sold for first quarters at about $27, Pittsburgh. Makers of large rounds for shells, possibly caught short, have paid all the way from $50 to $70 for billets made to shell steel specifications, discards 25 or 30 per cent, ingots chipped, and analysis fairly stringent though by no means difficult. Rods are $32 to $33, Pittsburgh.

Finished Steel

Effective Oct. 21 wire products were advanced $2 a ton. Bars, plates and shapes advanced $1 a ton about Oct. 25. Black and blue annealed sheets have advanced rather steadily. Tubular goods are unchanged.

Current quotations, f.o.b. Pittsburgh, unless otherwise noted, and in general for delivery at mill convenience, with premiums sometimes paid for prompt shipment, and with forward contracts difficult to place:

Rails, standard sections, 1.25c. for Bessemer, 1.34c. for open-hearth, f.o.b. mill, except Colorado.

Plates, tank quality, 1.50c.

Shapes, 1.50c.

Steel bars and bands, 1.50c., base; steel hoops, 1.70c. to 1.75c.

Iron bars, 1.559c. to 1.609c., Philadelphia; 1.35c., Chicago; 1.45c. to 1.50c., Pittsburgh.

Plain wire, 1.70c.; wire nails, $1.85 per keg, base; painted barb wire, 2.00c.; galvanized barb wire, 2.70c.; fabricated wire fence, 69½ per cent off list, in carload lots.

Sheets, blue annealed, 10-gage, 1.70c.; black, 28-gage, 2.10c. to 2.20c.; galvanized, 28-gage, 3.50c. to 3.60c.; painted corrugated, 28-gage, 2.30c.; galvanized corrugated, 28-gage, 3.55c. to 3.65c.

Tin plate, $3.10 to $3.20 for 100-lb. cokes.

Steel pipe, ¾ to 3-in., black, 79 per cent off list; galvanized, 63½ per cent off list.

Boiler tubes (less than carloads), 3½ to 4½-in., 71 per cent off list.

Structural rivets, 1.90c.; boiler rivets, 2.00c.

Notes on Chemistry and Metallurgy in Great Britain

(From our London Correspondent)

The Organization of Scientific and Industrial Research

We are a strange race. A national research scheme has been established. It was needed badly enough. But the net result is a ruling authority of successful politicians advised by ultra-scientific figure-heads.

There is first of all the establishment of a Committee of the Privy Council responsible for the expenditure of any new money provided by Parliament. This comprises the Lord President, the Chancellor of the Exchequer, the Secretary of State for Scotland, the President of the Board of Education, the Chief Secretary for Ireland, "together with such other Ministers and individual members of the Privy Council as it may be thought desirable to add." Under this category Lord Haldane, Mr. Arthur Acland, and Mr. J. A. Pease have been added to the Committee.

The second link in the chain is the advisory council which has to advise the Committee on:

(1) Proposals for instituting scientific research.

(2) Proposals for establishing or developing special institutions or departments of existing institutions for the scientific study of problems affecting particular industries and trades.

(3) The establishment and award of Research Studentships and Fellowships.

The first members of the advisory council are Lord Rayleigh, Dr. G. T. Beilby, Mr. W. Duddell, Prof. B. Hopkinson, Professor McLelland, Professor Meldola, Professor Threlfall, and Sir William M'Cormick. Of course Mr. Duddell, and to a certain extent Mr. Beilby, are open to suspicion as having some practical experience of applied science, but so far as the advisory council is concerned there is no direct representative of manufacturing interests. As for the Committee of the Privy Council and hope of representation of manufacturing interests by men who know depends on the fortuitous chances and mischances of who may be the members of H. M. Government at any given moment. There is in fact no prospect that the men who know will under the present scheme ever sit on the ultimate court of administration.

Yet despite these defects which your correspondent voices and which are very widely recognized, the scheme is by no means doomed. Salvation will be with the practical scientists on the Institutional Research Committees and in the sub-committees they appoint to deal with specific subjects. In spite of all the very learned or politically very successful figure-heads, in spite of all this top hamper one can still hope for good results. It is another question whether the over-all efficiency will not be capable of great improvement. In England figure-heads are necessary, and one supposes that it is only as a sop to the modern democratic unrest that they are not at once more numerous and more picturesque, and more uselessly arundite. According to all precedent there should at least have been added a spiritual peer, an eminent Assyriologist, a titled philatelist, the Astronomer Royal, and the President of the divorce court.

The Lighting of Factories and Workshops

The first report of the Home Office Departmental Committee on lighting in factories and workshops has just been issued, the Committee feeling that although the investigation is incomplete, and cannot be completed under the conditions prevailing at present, it is desirable to make available to the public the work already done, and to formulate certain recommendations regarding suitable standards of illumination. The report contains an immense amount of detailed information, and the subject is discussed at considerable length. The conclusions of the Committee in brief are that statutory standards of "adequate and suitable illumination" should be set up, and the standards suggested are minimum illumination on a horizontal plane at the floor level of 0.25 foot-candle in workrooms, 0.4 foot-candle in foundries, 0.1 foot-candle in passages, and 0.05 foot-candle in open spaces out of doors. These recommendations are subject to certain qualifications and exemptions, and are, of course, only provisional; they will serve, however, to indicate approximately the standards that will eventually be adopted, and will thus be of assistance to works managers, who will also find the mass of data contained in the voluminous appendices of the greatest value.

Market Prices

AUGUST, 1915.

Copper opened (3d) £72.10 and was £74 on the 4th, then fell away to £66.17.6 on the 13th. It subsequently improved a little to £67.17.6 on the 16th, but afterward continued to fall to £64.7.6 on the 23d. On the 25th a sharp rise of £3 occurred, and on the 26th £72.15 was reached, and £72.17.6 on the 27th. It closes lower at £68.17.6.

Tin opened £156.15 and dropped away to £150 by the 9th, and, after touching £152.6 on the 11th, to £149.10 on the 13th. It then hardened slightly but was again falling on the 18th and reached £148.5 on the 20th. On the 24th it was £150.5. This metal also participated in the rise on the 25th, and was £153 on the 27th, closing at £151.5.

Cleveland opened 65/10½ and touched 66/3 on the 5th and 66/4½ on the 9th and 11th, but afterward went lower, declining to 64/1½ by the 20th. On the 23d it was 64/7 and closed 65/6.

Hematite remained at 95/- throughout the month.

Scotch Pig opened 71/10½ and was 72/4½ by the 9th and on the 11th, but 71/10½ on the 13th and 70/31½ on the 20th. On the 24th it had recovered to 71/1½ but closed 70/9.

English Lead opened £24.15 and fell steadily to £21.10 on the 12th, recovering then to £22 and on the 24th to £22.10, closing same price.

The Dyestuff Situation—Papers and Discussion

Before the New York Section of Society of Chemical Industry

With the largest attendance which has ever occupied Rumford Hall, in the Chemists Club, the New York Section of the Society of Chemical Industry held a meeting on the evening of Oct. 22 for the presentation of papers and discussion on the dyestuff situation in this country. It is estimated that between 400 and 500 were present. Every available space was taken and many were forced to stand throughout the meeting, showing the live interest which is taken in this question. The chairman of the section, Dr. **William M. Grosvenor**, in opening the meeting said that regular business would be dispensed with and then gave over the conduction of the meeting to Dr. **Charles F. Chandler.**

Dr. Chandler gave a very interesting talk, showing the tremendous advantage which Germany has over America in making dyes in view of her many years of valuable experience and wonderful commercial development. In reviewing the discovery of dyes he said that Wolf in 1771 was the first to make an artificial organic dye. He treated natural indigo with nitric acid, forming picric acid. However, the epoch-making invention was Perkin's mauve (1856) and the present dyestuff industry really dates from that time. Dr. Chandler, who had visited many of the largest German factories, spoke of the wonderful and intricate development which has taken place in their dye industry. Friedrich Bayer & Company of Elberfeld, had in 1875 eleven chemists. In 1905 they had 300 doctors of philosophy—university graduates—and 8000 workmen. Is it any wonder that they can make dyes with this co-operation between university and factory? This company exhibited 161 colors at the Centennial Exposition in 1876. Not long ago they bought a square mile of land for additions to their factory. One of the newspapers recently gave an account of a plant under contemplation which was to make dyes in Long Island City. This plant was to be 40 ft. by 75 ft. A splendid account of the development of the coal tar industry is that by Friedlaender comprising thirteen volumes and describing the industry from 1877 to 1912. We ought to prevail upon our own Government that the Bureau of Census bring up to date and re-issue the catalog of U. S. chemical patents published in 1902. This would be a very valuable reference work.

DR. CHANDLER: *Hall's process for cracking gas oil—three plants in Europe of a total daily capacity of 21,000 gal. gasoline.*

In concluding Dr. Chandler eulogized the splendid work of the American WM. A. HALL in the cracking of petroleum (U. S. Pat. 24,491, 1913), and gave out some facts of history so far not published. In 1913 Hall put up a small plant at Greenpoint and Dr. Chandler was asked to pass expert opinion on the process and product. Hall started out from gas oil, which at that time was 3½ to 4 cents per gallon. Upon cracking this, 10 per cent gaseous and 90 per cent liquid products were obtained; of the latter 55.76 per cent consisted of "motor spirits," or gasoline. Later improvements, such as a second treatment, brought the yield of motor spirits well over 70 gal. per 100 gal. of gas oil. By actual tests it was found that an automobile required less Hall gasoline than that of the standard. For example, at 1600 r.p.m. 18 per cent more of the standard gasoline was consumed, and at 1200 r.p.m. 31 per cent more.

However, Hall found great difficulty in interesting capital in this country in 1913, and accordingly took his process to England. There he succeeded in obtaining funds and set up a plant with an output of 6000 gal. of motor spirits per day, besides valuable by-products, such as benzol (about 6 gal. per 100 of gas oil) and toluol (about 10 gal.).

During the last year the English Government assisted in the erection of a second 6000-gal. plant, and both plants are now working night and day. A third plant of 9000 gal. has been erected in Continental Europe.

Dr. Chandler then introduced the first speaker on the program, Dr. **E. E. Pratt**, chief of the Bureau of Foreign and Domestic Commerce, Washington, D. C.

Dr. **Pratt** presented a very able paper on "Do We Want a Coal-Tar Industry?" He first reviewed the German industry, giving statistics of capitalization and production. Of the world's production, valued at $92,150,000, Germany produced $68,300,000, or 74 per cent of the world's supply. Three factors are to be taken into consideration in discussing the American dyestuff industry, viz., raw materials, markets and technical skill. The United States has five times the coal supply of Europe, consequently this raw material is well taken care of. The market is about $15,000,000 annually. In technical skill we are not so well equipped, but this has been because of the lack of demand. Our schools can turn out all the chemists needed.

DR. PRATT: *Do we want a dyestuff industry? If so, it must be protected. What protection is necessary?*

Dr. Pratt reviewed the attempts of American manufacturers to make dyes since the first factory was started in Buffalo in 1879. He showed how the foreign interests had undersold American manufacturers at rates below market prices in order to drive them out of business. He quoted from a letter of the Benzol Products Company to the Commissioner of Corporations under date of Jan. 2, 1915, showing the relentless endeavors of the European interests to drive this concern out of business. At one time they lowered the price of aniline oil to such an extent that a price of 8.5 cents failed to secure the order for the American company when the regular market price was 10.9 cents per pound. In 1912 a British member of the European convention tried to induce the Benzol Products Company to go out of business, offering to sell them aniline oil so they could still make a profit on their contracts. "Such unfair methods as these must in some way be prevented. The total loss, direct and indirect, now being borne by American users of dyestuffs and dye wares amounts to not less than $1,000,000 per day. Our users of colors have reverted to dyestuffs and methods long since obsolete and almost forgotten.

"Since the outbreak of the war the five domestic concerns manufacturing dyestuffs have doubled their outputs. One new plant is now in existence and is producing 1000 lb. daily. Another plant will be ready for operation about Nov. 1, and still another capitalized at $15,000,000 has started plans for extensive works. We are making progress but there is a long way to go."

A report is now being prepared by Dr. Thos. H. Norton showing exactly the amount of each of the artificial dyestuffs now in current use in this country consumed by our various textile and other industries during the fiscal year 1914. Such a census of the dyestuffs has never been attempted before and should be a great help in establishing our industry.

"The most powerful weapon, however, in the hands of the foreign manufacturer is the power to throw out of gear our enormous textile industries and all dependent interests during the period inevitably necessary to create an American coal-tar industry. Recommendation will be made by the Department of Commerce that Congress, in whose hands this matter ultimately rests, shall pass such legislation as will, beyond the peradventure of a doubt, furnish the necessary protection. The experience of Canada, South Africa and Australia in this matter should be of great assistance. These countries have passed laws protecting their home industries. Dr. Pratt did not think the tariff question was of such importance as to warrant its discussion, as no final conclusion in that matter would likely be reached, and other means are at present of more importance.

The next paper was presented by Mr. **J. F. Schoellkopf** of Schoellkopf, Hartford & Hanna Co., Buffalo, N. Y., who have been manufacturing since 1879. He spoke on "The Aniline Industry from a Manufacturer's Viewpoint." He emphasized the fact that to be made economically, a great variety and a flexibility of machinery and equipment was necessary. The annual consumption of dyes is estimated at 40 million pounds. Probably close to 1000 different colors are used and no two are made exactly the same. About one dozen colors constitute 75 per cent of the production. The European factories have a larger producton than ours and can consequently run cheaper. The Farbwerke-Hoechst has 300 chemists, 100 of which are analytical and the other 200 have charge of the manufacture of about 500 colors, so that one chemist has only two or three colors under his direct supervision. Here in America people expect one or two chemists to control the manufacture of a thousand dyes and insist upon automatic processes of manufacture. It is absolutely necessary for our American factory heads to realize that, for example, sulphur black and direct black are as different as soap and wood pulp.

MR. SCHOELLKOPF: *Dyestuff manufacture does not lend itself to mass production. A very important problem is the manufacture of the intermediates.*

The most serious difficulty in introducing the dyestuff industry in this country is the fact that it does not lend itself to mass production. There are too many different kinds and shades of dyes necessitating frequent changes in apparatus and methods during the course of the year. This is a distinct disadvantage from an American point of view. The United States has always been most successful in mass manufacture of products of universal use. For instance, the manufacture of automobiles in this country is by far greater than anywhere else. American high cost of labor and natural inclination toward mechanical work favor such products as the automobile.

A very important phase of the dyestuff problem is the manufacture of the intermediates, such as Michler's ketone. We need a large ready stock of these. Some years ago Schoellkopf was influential in getting our government to place these on the free list, since they could be made much cheaper in Germany than in this country. We are now making intermediates in this country, but by no means enough. Mr. Schoellkopf thought that the suggestion made by Mr. I. F. Stone in his address at the Exposition of Chemical Industries (page 663 of our issue of Oct. 1, 1915) in regard to the Government manufacture of intermediates was timely.

In order to show that the manufacture of dyes was not an easy matter and required considerable experience, a list of some of the necessary apparatus was given. This included nearly every variety of apparatus known to the chemical industry. Since the dyestuff industry is subject to change of style a constant shifting of manufacture and, therefore, a great flexibility of apparatus is necessary.

Quite a few German colors are patented in this country for which there can be no competition. But fortunately most of the colors that now control the market are made according to patents which have expired. Mr. Schoellkopf said his own factory had been able to lower the prices from year to year by applying improved methods to old products. This they had done rather than try to make a great variety of new colors. They are making but 136 different dyes out of a possible 1000 now demanded by the textile and other manufacturers. Viewed from a manufacturer's standpoint he said the situation was also difficult owing to the shortage of supplies, including sulphuric and other acids.

Mr. Schoellkopf cited a number of stories from the daily press which greatly amused the audience. One newspaper account contained the recommendation of devoting a "room in each textile mill" for the manufacture of the hundred or more dyes required for that mill.

In concluding Mr. Schoellkopf summarized the immediate requirements of the American color industry as follows: (1) Cheap heavy chemicals; (2) cheap benzol, toluol, etc., (3) large supply of intermediates; (4) co-operation of the United States Government.

A paper on "The Dyestuff Situation in the United States" was then presented by Dr. **Thomas H. Norton** of the Bureau of Foreign and Domestic Commerce, who reviewed the situation and discussed the part of the Government in alleviating the situation. The country is now manufacturing enough aniline oil to satisfy the normal demand. The future depends on what the legislature will do next December. In 1913 about 3000 short tons of colors were made here. The imports were 25,000 tons, of which 22,000 tons came from Germany. In 1916 over 9000 tons will be made and by 1917 our production ought to be 16,000 tons.

DR. NORTON: *A plea for unity in the dye industry, a Government factory for intermediates, a Bureau of Standards for Dyestuffs.*

The largest hosiery mill in the United States and in the world employs 2500 operators. Ordinarily it requires 500 pounds of dyestuffs daily to cover the needs of its dyehouse. Four weeks ago its stock of colors had dwindled to half a barrel. About 160,000 dozen pairs of hose were stacked up awaiting dyes, and more than 1000 operatives were laid off.

Dr. Norton said that despite the efforts of the Government to secure the free passage of European dyestuffs to this country it has not succeeded in releasing more than 50 tons of dyestuffs of German origin since the middle of March, 1915. The powerful association of hosiery manufacturers has agreed to bear the burden of increased tariff duties on dyes of foreign origin, if that is necessary to secure the establishment of an independent American industry.

Dr. Norton made a strong plea for *unity* in the American dye industry. Financial, technical and commercial unity is absolutely necessary for success. He made the following recommendations:

(1) A Government factory for the production of the intermediates as proposed by Mr. Stone.

(2) A Bureau of Standards of Dyestuffs which would set a standard in the purity of dyes, would recommend best methods of dyeing wool, silk, etc., with the various dyes, would protect and help along the young industry and would serve in general as a bureau of information.

(3) A corporation made up of members of the various dyestuff *consumers*—all dyestuffs to be purchased through a central agency, which agency would be assisted by the national bureau. All consumers who would purchase imported dyes at "dumping" prices would be penalized or ruled out altogether.

Mr. **W. H. Childs** of the Barrett Mfg. Co. then presented a paper outlining the policy of the American Coal Products Co. and its subsidiary, the Barrett Manufacturing Co. He said that the manufacture of aniline oil was started by the Barrett Mfg. Co. in 1899, but was not a success, mainly on account of the competition from the foreign "Kartels."

MR. CHILDS: *History of Benzol Products Company. We need a protective tariff and a Scientific Tariff Commission.*

Later the Semet-Solvay Company and the General Chemical Company, together with the Barrett Company formed the Benzol Products Company. By 1913 this company produced 20 per cent of the aniline oil consumed in this country. The foreign concerns tried every means in their power to drive them out, but they continued manufacturing even though they lost money every year. Then came the war. On Jan. 1, 1915, they started manufacturing at their new plant at Marcus Hook, N. J., and are now producing a quantity in excess of the total consumption prior to the war.

Mr. Childs discussed at length the matter of protective legislation. We must realize that the peace perils of Germany and Japan are far more serious than their war perils. Tariff revision is a necessity.

Mr. Childs advocated the formation of a *scientific tariff commission*, this commission to be altogether non-partisan and to be composed of men and women such as Perkins, Edison, Logan, Byllesby, Mitchell, Jane Addams, etc. This commission would study the economic problems of the present and make well-founded recommendations to the Government.

A paper on "Common Sense on the Dyestuff Question" was read by Dr. **J. Merritt Matthews**, consulting engineer of New York City. He said that a great many textile manufacturers have the idea that dyes can be made in a small room by quick and simple means; they have not the faintest conception of the complexity of the aniline dyestuff manufacture. He deplored the propaganda which has been carried on by the newspapers, without doubt in good faith on their part, for numerous wildcat schemes for making dyes; they did not realize the harm they were doing by causing the public to believe the problem was solved and no further difficulties would be encountered.

DR. MATTHEWS: *Tariff protection for the intermediates is most important. Our country never prepared in the military sense without an "intermediate" industry.*

One of the most amusing of Dr. Matthews' stories was that of the owner of a large cranberry bog who wanted to make "cranberry red" from his cranberries, extracting the red dye without in any way impairing the food value. Dr. Matthews pointed out that the crux of the situation lies in the economic production of the *intermediates*, as well as ready supply of sulphuric acid and other necessary chemicals. What this country requires more than anything else to relieve the dyestuff situation is the firm and permanent establishment of the manufacture of the intermediates. We need tariff protection not merely for the dyestuffs, but chiefly for the intermediates, such as Michler's ketone.

It is to the Government's best interests to protect and foster factories for the production of the intermediates, not only for the sake of the dye and textile industries but also on account of the *military* importance of these factories in time of war.

Mr. **John P. Wood**, president of the National Association of Woolen Manufacturers, gave a short talk on the consumer's interest in dyestuffs, in which he stated that there was already sufficient power vested in the Government authorities to prevent dumping, provided it was rightly exercised, and he thought it was going to be a difficult matter to adjust conditions from the standpoint of tariff. The chemists must realize that the tariff is a political question, and they must not ignore present political conditions. The situation is, of course, grave, and the consumers are anxious to do all in their power to foster an American industry so that a repetition of the present conditions cannot occur. He explained the difficulty of obtaining Government action, and the long time needed for proper study of the tariff question. In a certain case a study of only one schedule occupied a period of two years, and then the commission which had made the study reported to the Government that its results were only partial and that it had not adequately finished the work.

MR. WOOD: *We need a tariff not only on dyes in bulk but on dyes that enter the country on cloth, leather, etc.*

He said the dyestuff industry was created out of a protective policy and the same policy ought to be followed now. But we must not only have a duty on the dyes in bulk, but also on the dyes that enter the country on cloth, leather, etc. Proposals made must take into account the fact that consumers need dyes now, immediately, and whereas ten years may ensue before a complete industry is established here, in the meantime the consumer needs the dyes and should be able to get them from somewhere.

Mr. **John Alden** of the Pacific Mills, Lawrence, Mass., commented further on the consumer's interest in dyestuffs. He said that our present supply of dyestuffs consisted of the following: (1) Old stock; (2) small amounts from Switzerland and England; (3) indigo shipped here from China; (4) colors from mills who have more than they need; (5) colors made in this country. To-day the mills are dependent on the last three items with the indigo from China being more or less uncertain. It costs 1 cent per yard more to produce fabric using the Chinese indigo. Many mills would be shut down if it were not for the colors made in this country from our own intermediates. Prices of dyes are very high and it costs more to produce the colors on cloth. For example, with the American navy blue the cost per yard of a number of goods has increased by more than 5 cents as compared with the German dye used before the outbreak of the war. In the same way the cost has increased for aniline black by 1 cent per yard, for wine by ¾ cent per yard, and for para red ⅞ cent per yard.

MR. ALDEN: *The shortage of dyes has quite materially increased the cost of dyed fabrics. This is serious.*

He said that the public had been led to believe through news from various sources that the dyestuff problem was practically solved and consequently the textile manufacturers had been prevented from raising the prices on their cloth very much.

Dr. **Wm. H. Nichols**, chairman of the board of the General Chemical Company, emphasized the great difficulties in carrying on the work of making dyes, and urged that great care be taken in starting new enterprises. He said that colors and intermediates cannot be created merely from the wish to do so, and that a great injury had been done by giving people the view that it is easy to make them. He attributed the success of the industry in Germany not

DR. NICHOLS: *Opening of general discussion. It is very difficult to make dyes efficiently on a large scale.*

merely to government protection, but to the intense application and devotion of the German to the science of chemistry.

Dr. **Chas. L. Reese,** chemical director of the du Pont Powder Company, said that his company is not manufacturing dyes and is not in a position to do so. It is making some intermediates for its own use, but does not intend to go into dyestuff manufacture.

Dr. **Wm. Beckers** of the W. Beckers Aniline & Chemical Works of Brooklyn, N. Y., considered protective tariff legislation as the most vital point in the whole dyestuff situation. The alizarine and indigo derivatives are still on the free list because formerly these dyes were agricultural products which could not be "raised" in this country on account of unsuitable climatic conditions. In consequence of these alizarine and indigo dyes being on the free list, our textile mills have favored these and slighted the aniline dyes. If this is continued the former products are apt to take the place of aniline colors, sulphur colors, etc. The carbazol products are the latest of this class, and the steady growth of these colors could result in their being developed to such an extent as to hurt the aniline dye industry. "The American dyestuff industry is a baby giant still asleep in his cradle, and it is our duty to see that his body and all of his limbs are properly developed and not one of his legs cut off."

DR. BECKERS:

Alizarine and indigo derivatives are still on the free list. This is a discouragement for the manufacture of aniline dyes.

Mr. **Herman A. Metz,** formerly Comptroller of New York City and president of H. A. Metz & Co., said that he represented all sides of the industry, being manufacturer, importer and consumer, and had also had a great deal to do with the tariff question. He said he had always advocated duty on all dyes or none, but that consumers here had backed up the free importation of alizarine dyes, as it of course meant a cheaper product to them and there did not seem to be any likelihood of their being made here. He said the situation demands immediate action as the consumers need the foreign dyes and are going to need them all during the time that the American industry is being developed.

MR. METZ:

The textile industry is much more important than the dyestuff industry. Textile men have a right to buy as cheaply as possible.

The American textile industry Mr. H. A. Metz considered much more important than the American dye industry and we must not impair or destroy the one for the sake of the other. "The dumping clause is all nonsense. The textile man has a right to buy at the lowest price obtainable. Everything else is theory and bunk."

Dr. **Marston T. Bogert** of Columbia University pointed out that the dyestuff industry is primarily dependent upon properly trained chemists. "The industry of producing the chemist is the fundamental industry of all." We ought to establish in this country an institute such as the Kaiser Wilhelm Institute in Berlin. The American university cannot very well meet the situation of supplying the proper material as regards efficiently trained chemists unless the country assists the university in its endeavors.

DR. BOGERT:

The industry of producing the chemist is the fundamental one. We need a Kaiser Wilhelm Institute in this country.

Professor Bogert was the last speaker. After a unanimous vote of thanks to the several speakers on the program the meeting adjourned at a quarter to twelve—one of the longest and most interesting meetings ever held at the Chemists' Club.

Coming Society Meetings

The New York Section of the **American Electrochemical Society** will hold its second regular meeting of the season jointly with the Illuminating Engineering Society on Thursday, Nov. 11, at 8 p. m., at the United Engineering Societies Building, 33 West Thirty-ninth Street, New York. The subject of the evening will be "Electrical Phenomena in Vapors and Gases," and the following interesting program is announced:

"Unstable States in Arc and Glow," by Mr. Walter G. Cady, Wesleyan University, A. E. S.

"Gaseous Conductor Light," by Mr. D. McFarlan Moore, Edison Lamp Works, I. E. S.

"Electric Arc in Complex Vapors at Reduced Pressures," by W. A. Darrah, Mansfield, Ohio, A. E. S.

The speeches will be illustrated by experiments and lantern slides.

Other meetings and lectures during November are:

American Chemical Society (New York Section) at Rumford Hall, Chemists Club, Friday, Nov. 12.

Society of Chemical Industry (New York Section) at Rumford Hall, Chemists Club, Friday, Nov. 19.

Franklin Institute Lectures, Philadelphia, Pa.:

C. H. Herty, University of North Carolina, "Turpentine Industry Development in the Southern States," Thursday, Nov. 4.

J. C. McLennan, University of Toronto, "Spectra, Their Origin and Some of Their Characteristics," Thursday, Nov. 11.

A. A. Michelson, University of Chicago, "On the Ruling of Diffraction Gratings," Wednesday, Nov. 17.

The School of Chemistry of the University of Pittsburgh

The new professional School of Chemistry of the University of Pittsburgh began its work on Sept. 27, 1915, under the deanship of Dr. Raymond Foss Bacon, director of the Mellon Institute of Industrial Research. A prescribed four-year undergraduate curriculum leads to the degree of Bachelor of Chemistry, and the staff of instruction includes the regular faculty of the university and fellows from the Mellon Institute of Industrial Research who are especially qualified in various theoretical and technical branches. This combination gives the new school the opportunity to offer not only the usual undergraduate and graduate courses in chemistry and technology, but also specialized work under men who are experts in specific American industries. In addition, thirty special lectures by prominent chemists and technologists in the Pittsburgh district, have been arranged for the academic year 1915-16. Attendance at these lectures is required of the student body, but they are also open to the public.

The professorate of the new school is constituted as follows: Alexander Silverman, M.S., professor of chemistry and head of the department of inorganic, analytical and physical chemistry; David S. Pratt, Ph.D., professor of chemistry and head of the department of organic, sanitary, and micro-chemistry; Samuel R. Scholes, Ph.D., E. Ward Tillotson, Jr., Ph.D., and Edmund O. Rhodes, M.S., professors of applied chemistry; Benjamin T. Brooks, Ph.D., professor of chemical engineering; William A. Hamor, M.A., professor of chemistry; Henry A. Kohman, Ph.D., and Harold Hibbert, Sc.D., professors of applied organic chemistry; Leonard M. Liddle, Ph.D., and R. Phillips Rose, M.S., professors of organic chemistry; Lester A. Pratt, Ph.D., professor of inorganic chemistry; and C. C. Vogt, Ph.D., professor of physical chemistry. Thirteen assistant professors and ten instructors complete the teaching staff of the school.

Zinc Oxide from Lead Blast Furnace Slag, as in Operation at South Chicago

BY H. B. PULSIFER

When the "National" plant of the American Smelting & Refining Co., located at South Chicago, Ill., was dismantled[1] early in 1915 some of the buildings were spared

FIG. 1—GENERAL VIEW OF PLANT—DUMPS, CRANE, FURNACE BUILDING AND STACK

and the place was leased to Messrs. Hedges and Divine for the recovery of zinc oxide from the slag dumps.

B. F. Hedges had been superintendent of the refinery[2] for over seven years and R. D. Divine had been metallurgist at the same place for some years. These men had previously made several laboratory tests and short experiments, even, with the large blast furnace to study the expulsion of the zinc from slag on heating with limestone and coke. They had the courage and confidence to make alterations, install the additional equipment necessary and start operations at their own expense. Cheerful to relate, the experiment is successful; their hopes are largely fulfilled, and each day's operation adds to their profits.

The process consists of smelting the refinery slags in the lead blast furnace with additional lime and considerable coke on the charge; the furnace is run with hot top and the heavy zinc fume is collected in bags as the finished product of the operation.

The principle of the process is not essentially different from similar work as carried out at the Oker plant in the Harz[3] mountains or in California plants[4], which have smelted copper ores high in zinc with volatilization of more or less of the zinc. The condition of best operation as at present worked out is worth attention, while the successful prosecution of the experiment will doubtless be copied with renewed vigor wherever circumstances shall allow.

THE SLAG DUMP

The slag dump as left by the lead refining operations covering a quarter century covers a space of some 4 acres and contains a maximum of possibly 150,000 tons of slag running over 10 per cent metallic zinc. Fig. 1 shows the plant and the dumps as seen from the side next Lake Michigan; Fig. 2 is another view of the ground, this time looking east, toward the lake. Certain spots in the dump will probably contain as high as 15 per cent zinc; it will mostly average 12 per cent, but some piles of coal ashes will have to be moved to get at the slag under them. The slag is, of course, practically all that runs from the lead blast furnaces previously charged with the refinery residues. The zinc came from the skimmings off the refining furnaces after the

FIG. 2—CRANE ON DUMP (LOOKING TOWARD LAKE)

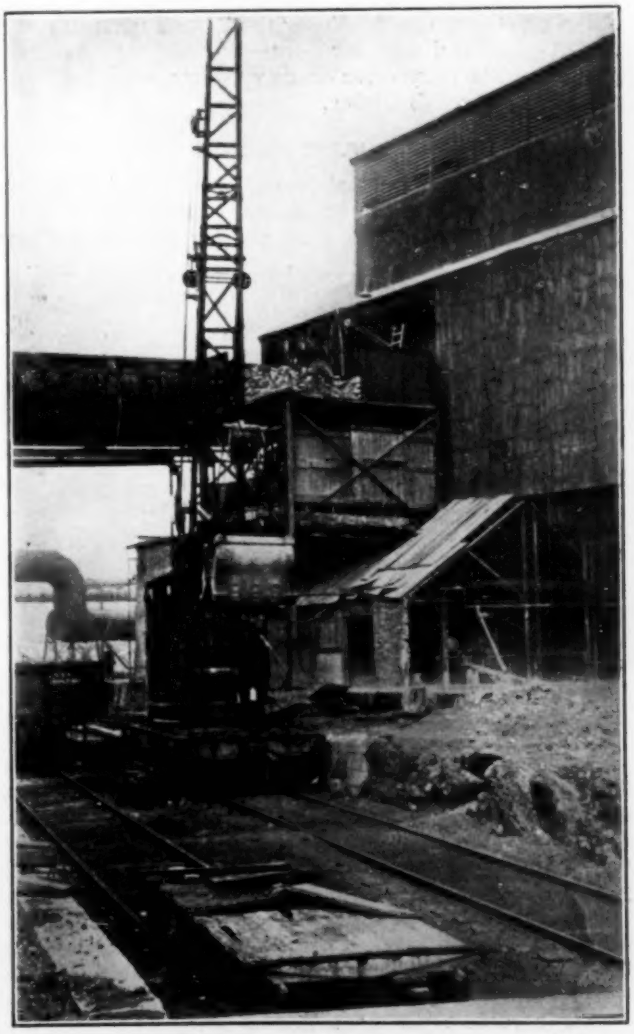

FIG. 3—CRANE AND SLAG HOPPER OVER FEED FLOOR OF BLAST FURNACE

[1]Mining & Eng. World, Jan. 2, 1915; p. 16.
[2]Mining & Eng. World, July 26 and Aug. 2, 1913.
[3]Eng. & Min. Journal, April 10, 1910; p. 819; and Eng. & Min. Journal, June 3, 1911; p. 1109.
[4]Mining & Eng. World, Feb. 10, 1912; p. 338. Eng. & Min. Journal, Feb. 29, 1908; p. 443.

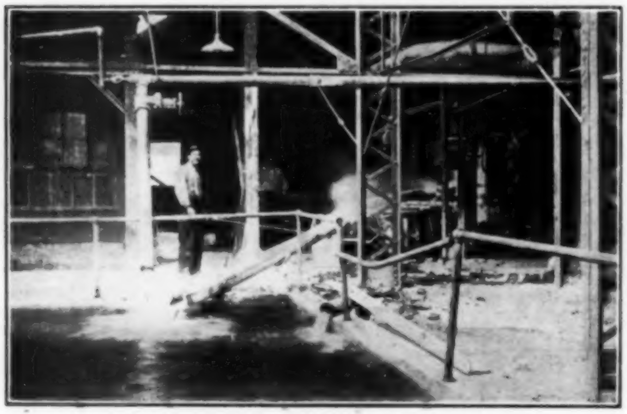

FIG. 4—SLAG FROM BLAST FURNACE RUNNING INTO GRANULATING TANK

desilverization by the Parkes process, this skim, along with many other residues and materials, constituting an important part of the blast furnace charges.

HANDLING THE MATERIALS

This is accomplished by the Browning locomotive crane, as seen in Figs. 1, 2 and 3. The crane digs out the slag and carries it to the hopper above and close to the feed floor of the furnace. The granulated slag is lifted out of the granulating tank by the same crane and deposited in cars or taken back to the dump on the water front, as desired. The limestone, coke, and any other materials can be brought to the furnace by the tracks, bins and elevator formerly used for the same purpose. The locomotive crane was new equipment supplied by Hedges & Divine.

THE BLAST FURNACE

The former bullion blast furnace, which had long been used in a shortened condition, was lengthened out from five to nine jackets on a side, making the furnace now

FIG. 5—FEED FLOOR OF BLAST FURNACE

about 46 in. x 156 in. at the tuyeres. The crucible and curb were built up another foot to get more fall to the granulating tank, while the inside capacity of the crucible was largely filled in, and has since become entirely so, slag and lead now flowing out together into the small pot forehearth. Raising the jackets shortened the curtain of brickwork above them up into the shaft but presented no difficulty. From the settling pot the slag flows out through a trough into the granulating tank well shown in Fig. 4.

Considerable experimentation as how best to feed the furnace finally resulted in low hand feeding from one side only. A charge ready to be pushed in is seen in

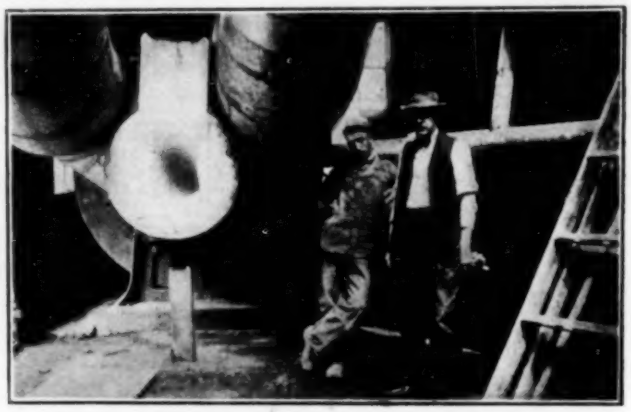

FIG. 6—FAN AND FLUES IN FAN ROOM

Fig. 5. A charge buggy is seen at the left of the print; only a few feet further to the left are the feed-spouts, which draw into the buggies from the overhead hopper as seen in Fig. 3. The top of the charge is kept nearly at the level of the feed floor; the top is usually red hot; a dense white fume subdues the flickers of the red (calcium) and green (zinc) flames which play up into the big brick flue head.

The furnace is now running smoothly on 12-oz. blast and taking around 65 tons per twenty-four hours. The charge consists of the dump slag, limestone and coke (partly coke breeze). Recovery of zinc is probably not

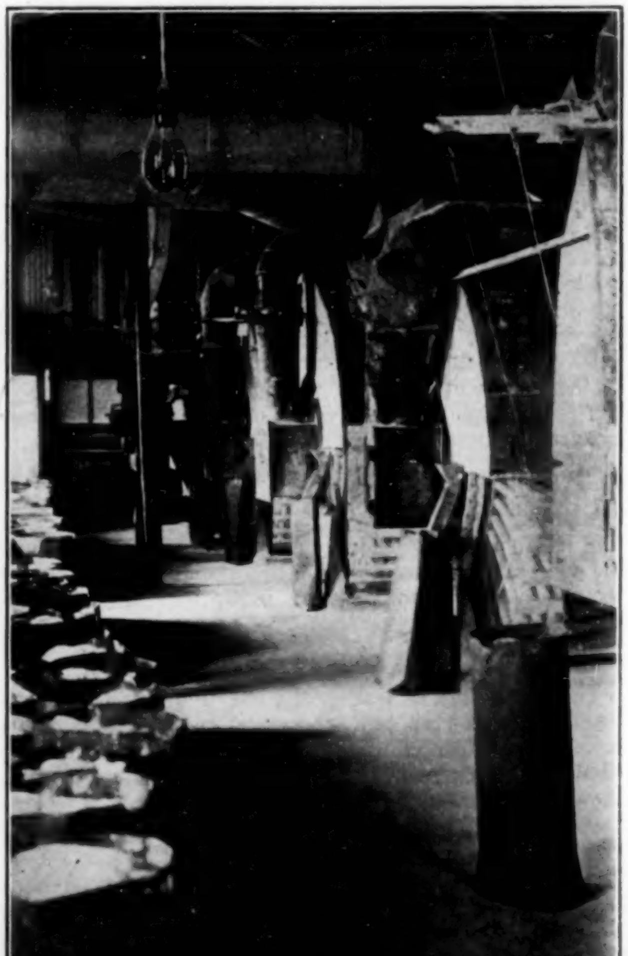

FIG. 7—BAG ROOM—DISCHARGE ENDS OF PRINZ & RAU MACHINES

over 50 per cent, for the granulated slag still goes some 5 per cent zinc. Besides the oxide driven off there is a noteworthy recovery in lead bullion and speiss—a ton or so each day. This bullion and speiss is, of course, silver-bearing. No change was made in the tuyeres for the new work; there are nine on each side, one to each of the cast-iron jackets; they are approximately 3.5 in. inside diameter. No crusts or hangs have yet appeared inside jackets or shaft after more than two months' steady running.

COLLECTING THE OXIDE

The white oxide which is evolved from the charge in billowy puffs is drawn through about 700 ft. of steel flue by a fan at the bag house. This fan is a No. 80 exhauster made by the Clarage Foundry & Machine Co. of Kalamazoo, Mich. An Allis-Chalmers direct-current

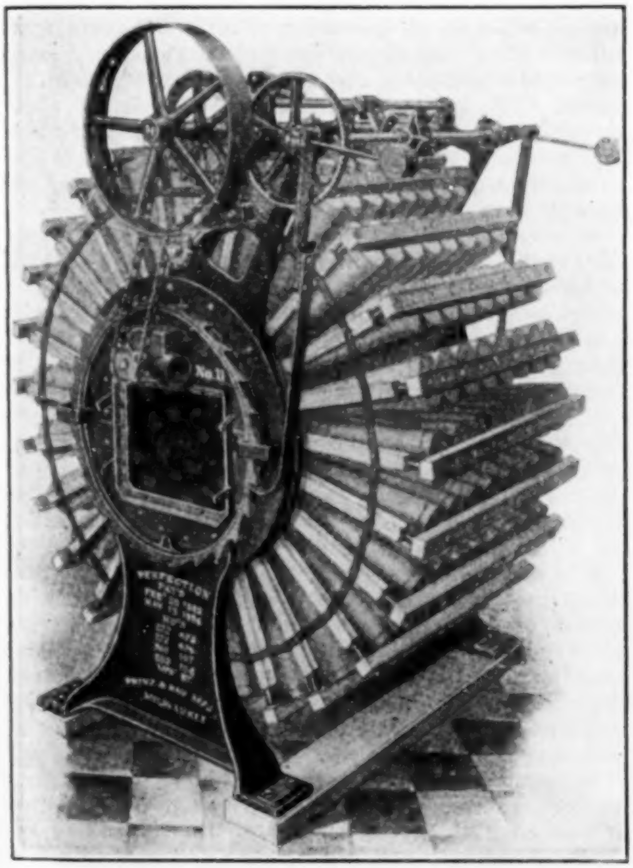

FIG. 8—THE PRINZ & RAU DUST COLLECTOR

motor, 25 hp., taking 220 volts and 96 amp. at full load, pulls the fan.

Fig. 6 shows the intake flue on the left; cooling air enters at the square orifice between that and the pipe to the bags, which comes out at the right. The temperature of the gas is held just under 200 deg. Fahr. A rather heavy fume settles out and builds up in the flue nearer the furnace; this is removed mostly through hoppers, but to get it all out the furnace must be temporarily banked so that men can enter.

Fig. 7 shows the last stage of the recovery. Here the oxide is collected in six Prinz & Rau dust collectors and the bags are filled. This bag room immediately adjoins the fan room. The flue from the fan is divided to supply each of the six machines; from the machines the collecting flue for the gases leads through another fan to the stack so conspicuous in Fig. 1. Unless a bag is damaged and leaks there is no visible exhaust from the bags. The Prinz & Rau machines have many small bags in lines under one supporting base for each line. As each line of bags comes vertical on the cycle the motion halts, the pressure has already died out in that line of bags and a sharp knocking dislodges the collected oxide; then the machine starts another notch to bring perpendicular the next line of bags, the cleaned bag is again inflated and passes downward around the axis. The dislodged oxide falls into a trough; a screw conveyor works it forward to the inclined trough, falling sharply into the paper bag. A full bag has averaged 55 lb. weight, the product containing about 74 per cent zinc and 6 per cent lead.

With the present fancy prices for spelter and oxide the recovery of some 3 tons of oxide a day represents a very respectable profit on the venture. Recovery is, however, far from what might be wished, while the cost of fuel is somewhat large. Further work ought certainly to remedy these defects. There is here a splendid example for further efforts on other dumps and at other plants. Not so very much of improvement would make the process workable on many a zincy dump; not much imagination pictures slag running from blast furnaces into converters (such as the Fink furnace) for the recovery of zinc after smelting for lead without intermediate cooling of the slag.

Removing Iron Scale by Pickling; Theory vs. Practice

BY CARL HERING

When iron is worked into sheets, wires, tubes, etc., the well-known bluish-black scale is produced each time that it is heated to the annealing temperature, or in the case of tubes, to the welding temperature. This hard scale must be removed before the metal can be again rolled or drawn, or before it can be tinned or galvanized. This is usually done by immersing the oxidized metal in sulphuric acid, which is termed "pickling."

Many persons are contented with the knowledge of this fact that iron thus coated with scale can be cleaned by immersing it long enough in sulphuric acid; the method has been known and used for generations. Those manufacturers whose motto is to "let well enough alone," that is, those for whom the methods of their fathers and grandfathers are good enough, are satisfied with this process.

The progressive manufacturer, however, who believes in looking after leaks, will do well to study this process more carefully. This black oxide of iron is Fe_3O_4 and it will be found that this is not soluble in sulphuric acid, at least only with difficulty at objectionably high temperatures. In a test recently made by the writer, a piece of the scale alone, without any metallic iron, was immersed for a prolonged time in rather strong sulphuric acid (sp. gr. 1.2); no gases were evolved and it was found to have lost no weight. It may be that some varieties of Fe_3O_4 are soluble, but this hard, bluish-black kind produced in the annealing furnaces, does not seem to be. At rather high temperatures solution is claimed to take place, but such temperatures cause acid fumes to be generated which are very objectionable.

A possible reason for its not being soluble is the equation $Fe_3O_4 + 3H_2SO_4 = 3FeSO_4 + 3H_2O + O$ which shows that free oxygen would have to be evolved if it were soluble. As this oxygen was combined with the iron it presumably requires a supply of energy to free it. Moreover as this oxygen must be changed from its solid form in the oxide, to the gaseous form, still more energy is required to supply the latent "heat," or more correctly, the energy of volatilization.

As the oxide is already in a low state, from the energy standpoint, little if any energy can be expected to be set

free by its solution. Hence it seems to be necessary to supply some energy from external sources. In the usual pickling process this is supplied by the dissolving of some of the metal itself, whereby good metal and acid must be consumed.

The action in the usual pickling process is therefore not a direct solution of the oxide. The scale is removed partly by dissolving the iron underneath it, and partly by forcing it off by generating hydrogen gas between the scale and the surface of the clean metal by the dissolving of the metal by the acid. It is possible that some of the hydrogen evolved by the dissolving of the iron, combines with the oxygen which must be set free, and that an actual solution of the scale then takes place in part at least; if so, less external energy would have to be supplied.

But in any case, the action in the usual pickling process is dependent fundamentally on the dissolving of some of the good metal, and not on the dissolving of the scale alone. The dissolving of good metal is not an incident in the process, but is a necessary part of it.

The process is therefore intrinsically incorrect in principle, as it is not a true dissolving of the scale, but must consume good iron and a corresponding amount of acid. The scale is not dissolved (or only partly) but the good metal is.

In the electrolytic process, however, the action is reversed; the scale is rendered readily soluble and the metal insoluble, hence it is correct in principle, the scale alone being dissolved. In this process, first brought out by C. J. Reed, and patented by him, the iron is made the cathode, not the anode as was suggested before. In an experiment recently made by the writer, a sheet of this scale alone without any metal attached, was made the cathode in sulphuric acid, and it was found to go into solution very readily when a current was passed, thus showing that when made the cathode, this oxide dissolves readily. It is not reduced to metallic iron, but goes into solution as oxide.

The reason, apparently, is that the tendency to develop hydrogen at the cathode reduces this higher oxide to a lower one, which then is soluble chemically; or perhaps the higher oxide or the partially reduced oxide is dissolved electrochemically, as we know it is in the case of the peroxide of lead on the cathode in a nitrate of lead bath.

Another factor is that the energy which it seems must be supplied when this oxide is to be dissolved in sulphuric acid is now supplied by the current, and it is certainly much cheaper to generate this energy in a dynamo than by dissolving good metallic iron in sulphuric acid, as in the ordinary pickling process of our forefathers.

But whatever be the explanation, the facts are that this oxide is readily dissolved in sulphuric acid when made the cathode. It is also a fact that when the current density is high enough to keep the clean metal covered with hydrogen, no good metal will be dissolved. Hence it is correct in principle; it will dissolve the scale only, will not dissolve any good metal, and will require the consumption of only as much acid as is necessary to dissolve the scale.

Although the amount of good metal and acid consumed in the ordinary pickling process, and saved by the electrolytic process, may be small relatively to the weight of the article pickled, yet when many tons of steel are cleaned per day, as in some large works, the value of these unnecessary wastes amounts to considerable. Mr. Reed (see Trans. American Electrochemical Society, Vol. XI, p. 182) estimates that this saving would be about 50 to 75 cents per ton, amounting in a single works to from $2,000 to $3,000 per day.

Another advantage lies in the fact that the oxide is sometimes formed in rather deep pits. To remove this by the ordinary pickling process would require a prolonged immersion, which would dissolve much good metal and probably make new pits, besides appreciably changing the thickness of the wires, sheets and tubes. The cost increases greatly when the oxide is in deep pits or adheres so tightly that it is difficult to dissolve the metal beneath it. While in the electrolytic process the oxide in such pits merely requires a longer treatment, but does not dissolve any metal, nor does it consume any acid uselessly.

In the case of tubes, the removal of the scale by the ordinary pickling process, sometimes involves the consumption of so much of the good metal that the tubes become seriously roughened and reduced in size and strength.

The anode in this process is most conveniently made of lead. The ordinary scale is removed in about a minute's treatment, less when thinner and more when thicker. The cost of the electric energy is very small, amounting to only a few cents per ton of wires and sheets. The iron comes out of the bath almost white, resembling silver, in marked contrast to the dirty gray appearance in the ordinary pickling process. It is then probably also in much better form for galvanizing and tinning.

In a recent test made by the writer under the ordinary conditions of pickling, that is, with dilute acid and at high temperatures (near the boiling point), the consumption of steel from sheets from which the oxide had been removed, was found to be about 1¾ lb. per thousand square feet per minute of immersion. It is, therefore, quite great, amounting to many tons per day in large works. Roughly, the acid required to dissolve this metal has about the same money value as the steel, or a little more, assuming the latter to be of good quality and to have had considerable work done on it. Both are unnecessarily wasted, as the above does not involve the acid usefully used to dissolve the scale.

Moreover, the surface of the steel which had been thus treated for about 50 per cent longer time than required for the pickling, was found under the magnifying glass to be full of fine pin holes and to be porous, hence would require far more tin or zinc to coat it, if, indeed, it could be well coated at all. A corresponding test made under electrolytic pickling conditions, while current was flowing, showed that no steel was dissolved.

In another test made by the writer, one electrode was made of a slab of scale alone (without iron), the other of cleaned iron, the solution being the hot, dilute one used for ordinary pickling. This was found to act as a battery of about 0.12 volt, the current in the liquid flowing from the iron to the scale, hence dissolving the iron. This shows that in the ordinary pickling operation, a local electrochemical action exists which dissolves the iron at the exposed parts.

A statement often made, especially by those who have little respect for scientific investigations, is that in specific cases practice has shown theory to be wrong. The present case is one in which it may be said that theory has shown the practice of many years to have been wrong.

The present war, so disastrous to Europe, has given a marked impetus to exports from this country, and if by reducing the cost of manufacture by such saving of waste and by other economies, the selling prices can be reduced, this country might be able to enjoy the markets of the world after the war. It is the well-known lack of attention to the saving of waste and to the smaller economies, which is an important factor in depriving us of the markets of the world in competition with other nations which give more attention to such details.

A Rapid Precise Standardization of Acid Solutions

By MERLE RANDALL AND CHARLES C. SCALIONE

A choice of a reliable method for the standardization of acid solutions has been the subject of extensive researches. We shall not attempt to devise a new method. We wish, however, to bring to the attention of analytical chemists, and to adapt to the technical laboratory, the sodium carbonate method used by Richards and Hoover,[1] in the determination of the atomic weights of carbon and sulphur.

This method has the advantage of extreme simplicity, accuracy and rapidity.

Aside from the personal factor of the analyst, the accuracy of a standardization depends on the accuracy with which the acid is measured and upon the definiteness of composition and amenability to weighing of the standardizing substance. Barium sulphate is of indefinite composition, very difficult to filter and weigh, and can be used only for standardizing sulphuric acid. Silver chloride has a definite composition, but its application is limited to hydrochloric acid. The method is tedious, and without extreme precaution and large expenditure of time, its use is less accurate than the sodium carbonate method described below. Because of varying atmospheric conditions substances containing water of crystallization are of indefinite composition. Powdered substances, like Iceland spar, are not definite in composition due to the varying content of absorbed water. Sodium carbonate of sufficient purity, except in respect to water, is available in most laboratories. If not available it can be easily purified by recrystallization in glass or porcelain, or in an ordinary platinum dish if extreme precision is desired. Richards has repeatedly shown that the only reliable method of completely removing absorbed water and other gases is to fuse the substance. Sodium carbonate can be easily fused.

Procedure.—Weigh out roughly into a previously ignited and tared platinum crucible half a gram of pure sodium carbonate. Provide the crucible with a rose crucible cover and pipe stem delivery tube. (A hard glass delivery tube is satisfactory.) Heat slowly to fusion, on a pipe stem triangle, in a slow stream of carbon dioxide from a commercial carbon dioxide cylinder,[2] connected to the pipe stem delivery tube of the crucible by means of a rubber tube. Keep fused three minutes. Remove the flame and allow the salt to cool in the stream of carbon dioxide. While the salt is in a fused condition and cooling, the stream of carbon dioxide is increased. This serves to prevent the decomposition of any of the carbonate as well as to cool the crucible quickly. Run out from a tared weight burette[3] into a beaker flask a quantity of acid roughly estimated to be a little less than that required to neutralize the sodium carbonate employed. Carefully weigh the cool crucible containing the fused salt, then introduce it into the acid solution, covering the beaker with a watch glass. When violent action has ceased boil the solution a few minutes. Allow to cool and when fairly cold introduce a few drops of methyl red indicator[4] Complete the titration drop by drop, with acid drawn from the weight burette previously used. The process may, of course, be conducted with even less trouble by adding at first a slight excess of acid and titrating back with a very dilute hydroxide.

Experimental.—The researches of Richards and Hoover have shown that the accuracy approaches that of the atomic weights. The accuracy in less experienced hands is high. The following new data are presented:

Sodium carbonate containing 5.97 per cent of water was re-fused five times in a current of carbon dioxide. The successive weighings were, 8.43539, 8.43543, 8.43540, 8.43538, 8.43542. No change within experimental error took place.

Dilute hydrochloric acid was standardized by the above method. The results are given in the following table:

No.	Weight of Acid Solution	Weight of Fused Na_2CO_3	Na_2CO_3 per Gm. of Solution	Per Cent HCl
1	261.01	0.5247	0.002010	0.1507
2	151.24	0.3043	0.002012	0.1509
3	113.69	0.2286	0.002011	0.1508

A student using this method for the first time with a strong sulfuric acid solution obtained 26.32 per cent, 26.34 per cent and 26.33 per cent H_2SO_4. A complete standardization can be made in forty-five minutes. The method is applicable to any strong acid and with choice of a suitable indicator to any weak non-volatile acid.

We believe that this method of fusing sodium carbonate in a current of carbon dioxide is more rapid than any other method of bringing a standardizing substance to constant weight. The other manipulations require no more time than those of other standard methods.

Chemical Laboratory, University of California,
Berkeley, Cal.

[1]Richards and Hoover, J. Am. Chem. Soc. 27, 95, 108 (1915).

[2]Carbon dioxide from commercial cylinders is the most convenient. If it is not available carbon dioxide produced in a Kipp generator with acid and marble and passed through cotton to take up the acid spray and then over calcium chloride, will be found satisfactory.

[3]For ordinary work a volumetric burette may be used; but for accurate standardization the weight burette is recommended. A weight burette can be made from a thin-walled glass-stoppered separatory funnel of suitable size by drawing off a tip close to the stopcock. A small test tube provided with a perforated cork is a satisfactory covering for this tip during weighing. The pipette can be suspended from the balance beam while weighing by means of a fine wire loop. Ordinarily the time for weighing the burette is less than that required for the proper drainage of the volumetric burette.

[4]Methyl red is recommended but if not available methyl orange will be satisfactory. Methyl red will be found very advantageous as there is only a two-color change from alkali to acid while methyl orange shows three. For a full discussion see Richards and Hoover. *loc. cit.*

Thermal Principles of the Blast Furnace

BY J. E. JOHNSON, JR.

(*Continued from page* 720)

I had for several years past investigated the subject of the amount of the moisture in the atmosphere as measured by local determinations of the dew point, and as taken from the records of the Weather Bureau, with a view of determining the effect of a given weight of water-vapor on the economy of the furnaces, the ultimate object being to find the relation between the cost of removing the moisture and the value of the saving so made.

Curves of fuel consumption for the year, taken from the furnace books for the corresponding weeks in several years and averaged, were of exactly the same general shape as the curve of annual humidity, but, calculating the effect of the humidity on the basis given by Bell, failed to account for more than a small part of the effect produced.

No adequate explanation was forthcoming until an analysis of the top gases was made, which should have showed a very considerable quantity of hydrogen based on the moisture contents of the blast, but which actually showed very little. This proved very clearly that the hydrogen formed at the tuyeres by the dissociation of the moisture took oxygen from the ore at a higher level in the furnace, where the temperature was sufficiently low to permit the simultaneous existence of water-vapor and carbon, and that in this operation the hydrogen restored as much heat as the original water-vapor had absorbed for its dissociation, so that the explanation

of the loss caused by the presence of water, mentioned above, was not the true one at all.

It then became clear that the heat was absorbed at the tuyeres or in the bosh during the process of combustion (it being entirely impossible for water-vapor to exist in the presence of incandescent carbon) and, being a first charge on the assets of the combustion, was deducted from the already scanty supply of available heat, so that its effects were of the same order and degree, but of opposite kind from those produced by hot blast.

The calculations of available heat with moisture present have to be modified from those of dry blast, because part of the oxygen required for the combustion of the carbon is furnished by the moisture, and the air required per pound of fuel is accordingly diminished.

To illustrate, let us take the case of air containing 0.75 lb. of moisture per 1000 cu. ft., or (on the basis previously explained) per 75 lb. of air, corresponding to spring and fall conditions, with blast and critical temperatures as before, 1000 deg. Fahr. and 2750 deg. Fahr. respectively.

The oxygen in 75 lb. of air is 17.25 lb. and in 0.75 lb. of water is $\frac{8}{9} \times 0.75 = 0.667$ lb.; that is, $17.25 \div 17.917 = 96.28$ per cent of the total oxygen comes from the air.

The air per pound of coke is therefore $0.9628 \times 5.22 = 5.022$ lb. and the heat brought in by it is 1192.7 B.t.u.

The total heat of water-vapor per pound at 1000 deg. is 1552 B.t.u., and the water-vapor being just 1 per cent of the air by weight, the quantity brought in is 0.0502 lb., so the total heat brought in by it is 78 B.t.u. The heat of combustion and that brought in by the coke remain the same, so the total assets of the combustion become 6152.6 B.t.u.

The heat taken out by the nitrogen is 2594.6 B.t.u., that by the hydrogen is 52.4, and that by the dissociation of 0.0502 lb. of water is $\frac{0.0502}{9} \times 61{,}560 = 342.5$ B.t.u. The heat removed by the CO is, as before, 1431.6, or a total thermal expenditure of 4421.1 B.t.u., leaving as the heat available 1431.6 B.t.u. against 1697.5 B.t.u. with dry blast; all other conditions remaining the same. This is a reduction of 15.6 per cent, just about the difference in fuel consumption that is found in practice under the given conditions. If the same loss were referred to the 6000 B.t.u., which represent the approximate total heat development from 1 lb. of fuel, the loss would be 4.4 per cent, which is an insignificant fraction of the actual results in practice.

The results given in Fig. 1 were obtained by a series of calculations similar to the above.

It is hoped that these diagrams will have more than an academic interest to furnacemen, as they furnish an easy means of determining the probable results in fuel economy of any change in the temperature or humidity of the air. They also furnish the means of determining the increase in blast temperature necessary to counteract the effects of a given variation in moisture. While it does not now seem likely that we shall ever obtain stovemen who will determine the moisture from hour to hour, and proportion the blast temperature to meet it, the thing is not impossible; and if some genius would kindly invent a recording and direct-reading instrument for measuring the humidity of the atmosphere, this result might be achieved in fact.

These results, being based on what is supposed to be a new theory of the action of heat and moisture in the blast, will naturally be viewed with some skepticism, so that proofs of their substantial accuracy are in order.

Fortunately the data supplied by Mr. Gayley furnish an admirable opportunity. The critical temperature alone is lacking, but from the kind of iron made may be assumed to have been 2750 deg. Fahr. The humidity, before the dry blast was used, averaged about 5.25 grains per cubic foot, or 0.75 lb. per 1000 cu. ft., and the blast temperature was 720 deg. Fahr. After the application of the dry blast the humidity was about 2 grains, or, say, 0.3 lb. per cubic foot, and the blast temperature was 870 deg. Fahr. By interpolation on the diagram we find the available heat in the two cases to be 1090 and 1420 B.t.u. per pound of fuel respectively. The coke-consumption before the change was about 2140 lb. and, to be in inverse proportion to the available heats, should have been 1640 lb. after the change. Actually it was 1700 lb., a difference which is certainly no larger than might reasonably be expected, considering the many other factor varied. Notable among these is the increased ratio of CO_2 to CO in the top gases, with the correspondingly increased tendency of these gases to dissolve carbon from the fuel in the upper part of the furnace, and prevent its reaching the hearth.

This feature, of which, obviously, the diagrams can take no cognizance, is of the first importance in an exact determination of results.

At many works the effects of the higher humidity of the summer are masked by the fact that the furnaceman carries a higher heat in summer than in winter, either deliberately and for purpose of neutralizing the effect of the humidity, or simply because he finds that the furnace will stand more heat without sticking or other objectionable results. But at the furnaces with which the writer is connected, a constant temperature of 850 deg. is carried the year round, and under these conditions the variation in fuel is clearly apparent, the fuel per ton of iron being about 20 per cent more in the most humid weather than in the dryest. The critical temperature at these furnaces is known to be about 2750 deg. Fahr, the average low humidity is about 0.25 lb. water-vapor per 1000 cu. ft., and the average high humidity is about 0.95 lb. For these conditions we find from the diagram that the available heats are 1400 and 1160 B.t.u., which are in the ratio of 1.20 to 1, or precisely the same as the fuel consumption in the two cases.

In order to obtain a wider range of comparison, I have taken the work of a two weeks' period in two successive years (at precisely the same season in each) done by a small charcoal blast furnace, working with cold blast one year and hot the next.

The comparison is not very satisfactory, because the critical temperature could only be obtained approximately in one case and estimated in the other, the percentage of lime used being twice as great for hot blast as for cold, with a correspondingly great influence on the critical temperature (as will be explained presently). Moreover, in the cold-blast campaign a considerable quantity of cold slag was charged, to overcome the tendency to work "dry," which was not done in the hot-blast campaign.

The recorded fuel-consumption in the two cases was in the ratio of 1.7:1, while the available heats based on the probable critical temperatures in the two cases and without allowance for the remelting of the additional slag in the cold-blast campaign are as 1:2—a reasonable correspondence, considering the circumstances.

I recently found what appeared to be an authoritative statement, that at the Clyde Iron Works (England) the fuel consumption in January-August of 1829, 1830 and 1833, with cold, warm (300 deg.), and hot (600 deg.) blast respectively, was 8 t., 1 cwt., 1 qr.; 5 t., 3 cwt., 1 qr.; and 2 t., 5 cwt., 1 qr., or fuel consumption in the ratio of 3.42:1.56:1, while the available heats, with a

critical temperature of 2750 deg. and average moisture, are as 1 : 1.73 : 2.63, a correspondence which is not by any means accurate, but considering the magnitude of the saving and the probable effects of secondary results is not at all to be despised.

Other considerations of the same general kind in which the data are not available for quantitative comparisons will be given later, but will best be preceded by some remarks on the determination of the critical temperature.

Determination of Critical Temperature.—The paucity of published data of definite character on this subject led me to attempt direct experimental determinations.

This seemed a field in which a radiation pyrometer might be employed more conveniently than any other, and with the advantage of absolutely self-luminous bodies to observe. Accordingly, a Mesuré & Nouel "lunette" pyrometer was obtained. This instrument is not exact, and, for wide ranges of temperature, particularly at the upper or lower extremities of the scale, could not be trusted very far; but for a limited range near its center results obtained by any reasonably careful observer are closely comparable.

Many thousand observations were made with this instrument upon the iron and the cinder, where they flowed over their respective dams, at every stage of many hundred casts.

At first no connection whatever could be observed between the condition of the furnace, the kind of iron being made, and the reading of the pyrometer. Sometimes, it would show much higher temperatures with white iron than with gray, and, again, it would give the opposite result, until I almost gave up hope of getting any information as to the action of the furnace from it. But finally, I observed that the readings were influenced almost solely by the relative calcareousness or siliceousness of the slag, and the difficulty of interpretation then disappeared.

One or two things were eventually brought out with great clearness which are not recorded elsewhere, so far as I know, and are therefore given here, since, though they may be known to others, their publication may still serve to bring out valuable discussion.

The first point noticed was the absolute collapse of the old notion that gray iron was always made in a hot furnace, and white iron in a cold one. (The furnaces were working on basic iron, and the silicon was therefore limited to 1 per cent, so that gray iron in this case means iron with only about this percentage of silicon.)

The next observation was that, in spite of the common statement that black cinder is made because the furnace gets too cold, the black cinder, in reality, was very frequently much hotter than the light.

On the other hand, the old founders' saying that "lime gives heat to the furnace" was confirmed completely, the cinder being without exception hotter in proportion, as it was more limy, as long as the furnace continued to make good iron. Even when the iron became hard, the cinder might still be at its very hottest if very limy.

It was also noticed that the cinder always controlled the temperature of the iron, and that as long as no cinder came through the tap-hole the temperature of the running iron remained practically constant, but as soon as the cinder came the temperature of the iron went up considerably and became the same as that of the cin-

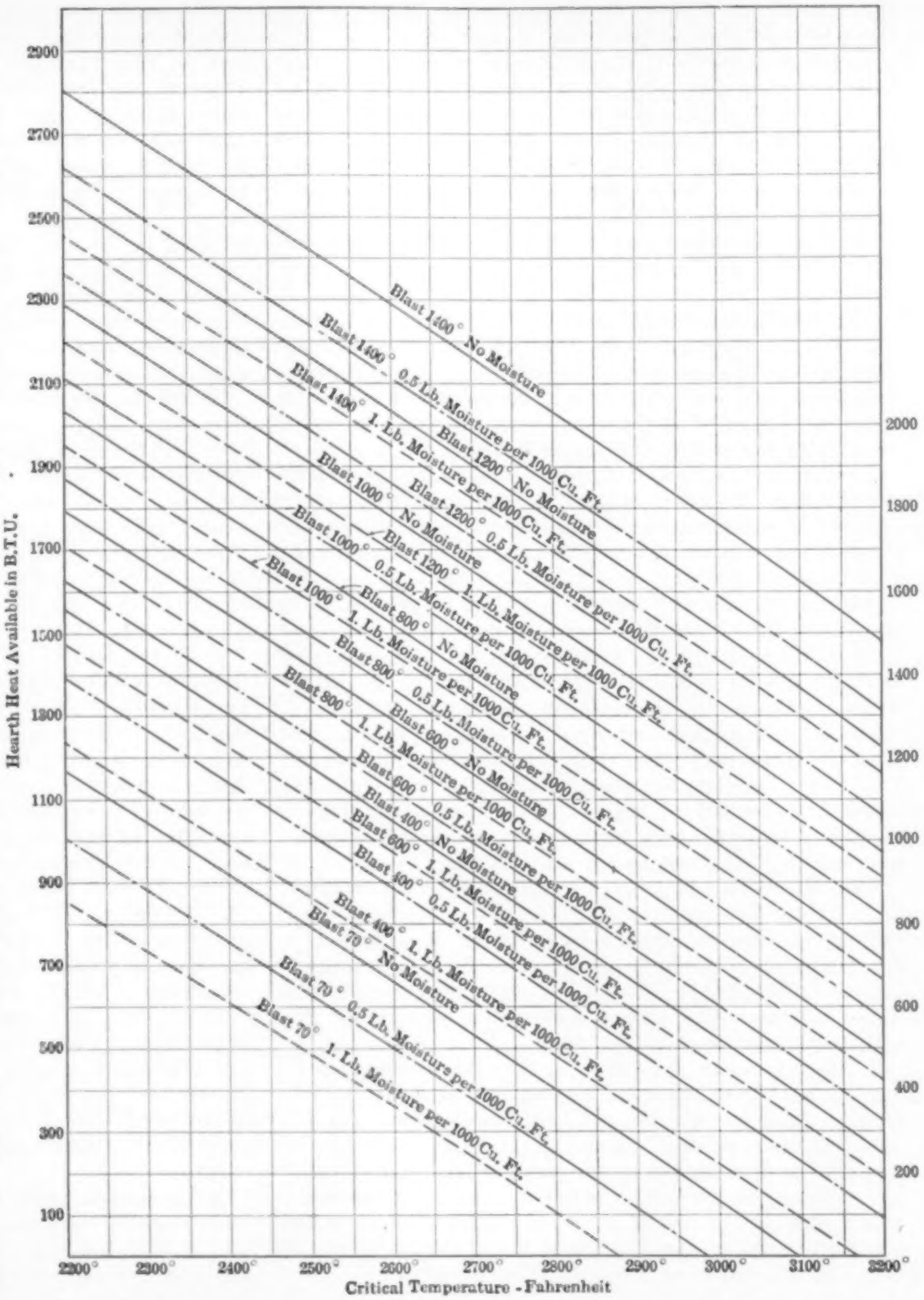

FIG. 1—HEARTH HEAT AVAILABLE PER POUND OF COKE, COUNTING 0.85 LB. OF FIXED CARBON ACTUALLY BURNED IN HEARTH, WITH DIFFERENT CRITICAL TEMPERATURES ALSO DIFFERENT BLAST TEMPERATURES AND DIFFERENT MOISTURE CONTENTS IN THE BLAST

der, which was always decidedly higher than the previous temperature of the running iron.

These observations, confirmed so many times that their accuracy for the given conditions could not be questioned, made it plain that, since the cinder became less fusible as it became more calcareous, it remained longer in the bosh, exposed to the heating action of the ascending gases, before acquiring the high fusion-temperture at which it could flow down into the hearth, while less calcareous slags melted sooner and ran down out of the range of action of the products of combustion.

The cinder, moreover, exercises a deterrent action on the iron as it drips down through the bosh, and by delaying its passage longer, as well as by direct contact, heats the iron nearly to its own temperature, a process which is completed as the metal passes through the layer of slag on top of the iron in the hearth.

The cinder requires not only to be heated up to its temperature of fusion, but far enough beyond this point to give it sufficient fluidity and consequent activity to remove the sulphur coming from the coke, and permit the dissolved oxide of iron to separate out.

So long as sufficient heat is produced in the hearth to impart to the cinder the temperature necessary to give this fluidity, the iron oxide is reduced and separates out; the cinder remains bright; and silicon can be reduced and can stay in the iron, making it gray. But when the temperature required is so high that sufficient heat for this purpose is not furnished in the hearth, the cinder becomes too thick and viscous to permit the operations mentioned; the oxide of iron remaining in it makes it black and, acting as a powerful oxidizer, prevents silicon from going into the iron.

This condition may arise in any one of three ways: (1) By an increase in the lime-content of the slag, raising its fusion-temperature; (2) by a reduction in the quantity of available heat, due to decreased temperature of the blast or increase of moisture; or (3) by a slip, bringing down into the hearth a quantity of improperly digested material.

It thus becomes evident that the temperature necessary, not only to melt the cinder, but to make it sufficiently fluid to perform its functions properly, is the "critical temperature," since the slag and iron must be brought to this temperature, and the final reduction of the ore must be performed above it (and, most probably, other reactions). What may for convenience be called the free-running temperature of the cinder is therefore taken in this paper as the critical temperature.

FACTS OF PRACTICE EXPLAINED BY THE CRITICAL TEMPERATURE

One of these is the fact that furnaces working on rich ores do not commonly show the low fuel-consumption as compared with those working on siliceous ores, which might be expected in view of the large quantity of heat required to melt the slag. The explanation seems to be that in smelting the richer ores the much smaller slag-volume available for carrying off sulphur, requires a much more calcareous slag, and therefore a higher critical temperature, which reduces the available heat per pound of fuel enough to offset largely the advantage of having less slag to melt.

The extremely low fuel-consumption of charcoal furnaces furnishes an illustration of the opposite kind. Having practically no sulphur in the fuel to contend with they can run on a very siliceous and fusible cinder, so that their critical temperature is several hundred degrees lower than that of coke furnaces smelting the same ore—which largely increases the amount of available heat.

The fuel-consumption of furnaces making ferromanganese is, on the other hand, out of all proportion to that of iron furnaces in view of the fact that the heat required for the reduction of MnO_2 is only 25 per cent more than for that of F_2O_3; but this again becomes explicable when we consider the temperature necessary in the two cases, which, though not definitely known, is known to be much higher for manganese than for iron. In the case of iron, nearly all the reduction is effected before the charge reaches the critical temperature; but with manganese this is far from being the case. The quantity of "available heat" required is therefore much higher, as well as the temperature of its application, and the fuel consumption per pound of manganese is therefore much greater.

Similarly the fuel-consumption in the production of iron with 3.5 per cent silicon is probably at least 20 per cent greater than that required for 1.5 per cent silicon iron, though the difference in the heat actually required for its reduction is only 7 per cent. But the silicon cannot be reduced at all except at high temperatures and the critical temperature is therefore raised, as well as the quantity of heat required above it, so that the fuel-consumption is augmented in correspondingly higher ratio.

It is interesting in this connection to consider why in order to make high-silicon iron with a reasonable fuel-expenditure a small hearth is necessary. The reason probably is that since the necessary high temperature cannot be secured by the use of calcareous slag (because such a slag does not allow the silica to leave it and be reduced to silicon) it can only be secured by a longer exposure of the charge to the products of combustion, and for this purpose the currents of both gas and dripping iron must be of smaller cross section, thereby virtually lengthening them and increasing the number and duration of the contacts of the dripping iron with the incandescent fuel—the condition most favorable to the reduction of silicon and its absorption by the iron.

If the claim here made for the existence and position of a "critical" temperature be admitted, it follows that the attainable economy of fuel is subject to a double limitation: (1) By the total development of heat produced in the furnace per pound of fuel, and (2) by the proportion of this heat available above the critical temperature.

A legitimate corollary to this proposition is, that the work done in the process may be divided into two parts, that done below the critical temperature and that done above it, corresponding approximately to the work done above the zone of fusion and that done below it, or, roughly, to that done in the shaft of the furnace and that done in the bosh and hearth. We may for convenience call these respectively the preliminary and the final work. The total heat introduced into and developed in the furnace being H_t and the part expended in the bosh and hearth in the final work being H_a (the "available" heat), the heat necessary for the performance of the preliminary work is $H_t - H_a$.

From the investigations of Bell and others we know with considerable accuracy the total quantity of heat required for the production of a unit weight of pig iron, and from the diagrams herewith given we can determine approximately the proportion of this which must be applied above the critical temperature. In view of the preceding discussion it is apparent that there must be a reasonably definite ratio between these two quantities or between the latter and their difference—in other words, between H_a and $(H_t - H_a)$.

This can be put in the form of an equation which will help to make the matter clear.

If we call the total heat required to produce a unit of

iron R_t, and the fuel required per unit of iron (calculated on this basis) n_1 (H_t being, as before stated, the total heat developed in the furnace by the unit of fuel), we have

$$\frac{R_t}{H_t} = n_1 \qquad \text{(A)}$$

or $R_t = n_1 H_t$, the equation, of which both sides were so magnificently and completely analyzed by Bell.

If, however, we denote by R_a the heat required, above the critical temperature, per unit of iron produced, H_a being the available heat and n_2 the fuel-consumption determined on this basis, we have

$$\frac{R_a}{H_a} = n_2 \text{ or } R_a = n_2 H_a \qquad \text{(B)}$$

Both A and B must be satisfied if the reduction is to be complete.

If we should increase the degree of oxidation of the fuel, and thus increase H_t without affecting H_a we would effect no fuel economy since we should do the preliminary work upon a larger quantity of ore than the available heat could take care of in the bosh. The furnace would consequently become cold and an increased quantity of fuel would have to be used to make good the deficiency in available heat.

If, on the other hand, we increased the available heat H_a without increasing the total heat H_t we should either change the grade of the iron enough to absorb the heat-excess or drive the heat up to the higher zones of the furnace, with those disastrous results which furnacemen know under the caption "too hot and sticking." But no fuel would be saved because no more heat being produced for the preliminary work no increase in the quantity of ore prepared for final reduction could take place, hence no increase of output for the same fuel.

It is thus seen that it is necessary to increase the two quantities of heat in the same ratio if any economy is to be achieved. Here the quotation from my former paper ends. It should be particularly noted that, as mentioned above, the mere conception of a critical temperature without determining what this temperature is and what controls it, is of little use and the determination that it depends upon the free-running temperature of the slag is almost as important and as useful in understanding the action of the furnace as the conception of the critical temperature itself.

In fact, the French metallurgist, M. A. Lodin, published in *Comptes Rendus*, Nov. 28, 1904, a brief note suggesting the critical temperature theory to account for the results of the dry blast, but used the fusion temperature of the slag instead of the free-running temperature as the critical temperature. He did not connect it up with the hot blast or the broad facts of practice nor give any quantitative results, and the suggestion did not receive any attention, as far as known to me. My own "disclosure" of the idea was made in patent applications filed April 9, 1903 (see U. S. patent 783,-044), and my original chart of "available heats" was dated and witnessed 1902. Since that time it has become evident that the term "available heat" is too loose, since heat not "available" in the hearth and bosh passes up into the shaft of the furnace and does useful work there so becoming available. I have therefore substituted the terms "hearth heat" for this and use the corresponding term "shaft heat" for that developed or carried into the shaft.

The first requisite to making and understanding such calculations is a table of thermochemical data and specific heats and I give below tables I, II and III of these quantities taken from Prof. J. W. Richards' "Metallurgical Calculations" and where necessary converted to Fahrenheit temperatures and British thermal units instead of calories.

This excellent work had not been published at the time the calculations in the article above quoted were made and the data available to me were not as accurate as those given by Professor Richards.

I have recently recalculated the hearth heats under different conditions in accordance with these more accurate data for the chart, Fig. 1. This is substituted for the original Fig. 1, as the results it gives are the same in principle but somewhat more accurate and the range of conditions covered is wider.

TABLE I

Element	Compound	Molecular Weight	Heat of Formation, B.T.U. Per Lb. Molecule	Per Lb. Element	Per Lb. Oxygen	Per Lb. Compound
Fe	Fe_2+O_3	112+48	352,000	3,145	7,330	2,200
	F_3+O_4	168+64	487,500	2,905	7,625	2,100
	Fe+O	56+16	118,300	2,115	7,390	1,480
C	C+O	12+16	52,500	4,375	3,280	1,875
	$C+O_2$	12+32	175,000	14,750	5,470	3,980
	CO+O	28+16	122,500	CO 4,375 C 10,400	7,650	2,790
H	H_2+O	2+16	109,000	54,500	6,530	5,806 to gas
Mn	$Mn+O_2$	55+32	226,000	4,110	7,060	2,600
	Mn_3+O_4	165+64	591,000	3,580	9,250	2,680
	Mn+O	55+16	163,600	2,985	10,230	2,308
Si	$Si+O_2$	28+32	324,000	11,580	10,130	5,400
P	P_2+O_5	62+80	657,500	10,600	8,210	4,630
Ca	Ca+O	40+16	236,600	5,910	14,780	4,220
	$(Ca+O)+(C+O_2)$	40+12+48	493,000	......	......	814
Mg	Mg+O	24+16	258,000	10,740	16,130	6,450
	$(Mg+O)+(C+O_2)$	24+12+48	486,000	......	......	662

It will be noticed that the chart is based on 85 per cent fixed carbon burned in the hearth which may seem strange as all good coke is much higher than this in fixed carbon. The reason is that the iron made takes up about 4 per cent of its own weight of carbon so that on the basis of a pound of coke of 89 per cent fixed carbon per pound of iron, 0.85 lb. carbon represents approximately the actual amount burned in the hearth with no solution loss, but when much of the coke is lost by solution, it is necessary to determine the actual weight

TABLE II—SPECIFIC HEATS OF GASES

Substance	Temp. Range F	Specific Heat Per Lb.	Specific Heat Per Cu Ft.	Volume of 1 Lb. in Cu. Ft.	Weight of 1 Cu. Ft. in Lb
H	0°-3,600°	3.37+ 0.00017t	0.0189+ 0.0000009t	178.23	0.00561
O	0°—3,600°	0.2104+ 0.0000104t	0.0189+ 0.0000009t	11.209	0.0892
N	0-3,600°	0.2405+ 0.0000119t	0.0189+ 0.0000009t	12.752	0.0784
CO	0–3,600°	0.2405+ 0.0000119t	0.0189+ 0.0000009t	12.804	0.0781
CO_2	0-3,700° F	0.19+ 0.00006t	0.023+ 0.000008t	8.102	0.1234
Air	....	0.234+ 0.0000111t	0.0189+ 0.0000009t	12.387	0.0807
CH_4	....	0.5929 "Kent"	....	22.301	0.04488
Carbon	0°482° F.	0.1567+ 0.0002t	....	Gas 29.85	0.0335
Carbon	482° to 1,832°	0.2142+ 0.00009t	....	....	....
Carbon	Over 1'832°	$.5 = \frac{216}{t}$	....	....	....
H_2O Gaseous	Up to 3,600°	0.42+ 0.000103t	0.021+ 0.000005t	....	....

TABLE III—SPECIFIC HEATS, ETC., SOLIDS

Substance	Temperature Range F	Sm.	Melting Point	Latent Heat Fusion, B.t.u
SiO_2	0-t°	0.1833+ 0.000042t	3450°	243
CaO	(Est.)	0.1715+ 0.000004t	......	......
MgO	Any	0.2420+ 0.00001t	......	......
$CaOCO_2$	68°-212°	0.2086	......	......
$\left.\begin{matrix}CaO\\MgO\end{matrix}\right\} 2CO_2$	68°-212°	0.2179	......	......
Al_2O_3	Any	0.2081+ 0.000°486t	About 4000°	917
Fe_2O	....	0.1456+ 0.0001t	......	......
	....	0.1447+ 0.0001t	......	......
eO	(Assumed)	0.1460	......	......
MnO	....	0.1570	......	......
MnO_2	....	0.159	......	......
$Mn_2O_3H_2O$	....	0.1760	......	......
Silicates:				
Mg_2SiO_4	32°-212°	0.220	2550	234
$MgSiO_3$	32°-2200°	0.301	2375	207
$CaSiO_3$	32°-2200°	0.288	2280	180
$CaAl_2Si_2O_8$	32°-2200°	0.294	2230	180
$Ca_3MgSi_4O_{12}$	32°-2200°	0.264	2190	170
$CaMgSi_2O_6$	32°-2200°	0.281	2400	180

of fixed carbon burned in the hearth. The results taken from the chart can be applied to this actual weight (in pounds) by dividing by 0.85.

We shall presently revert to this matter of solution loss and its consequences at greater length.

Need often arises to figure quickly the total heat imparted to the furnace by the coke under different conditions allowance being made for the CO_2 from different proportions of limestone, for different top temperatures, and different ratios of CO to CO_2 in the top gas; for this purpose; a chart, also from "Notes on the Physical Action of the Blast Furnace," is reproduced as Fig. 2, from which this quantity may be directly taken. $L = 0$ means the condition when no limestone is charged and $L = 1$ means one pound per pound of coke, intermediate quantities can easily be interpolated by eye with sufficient accuracy. This diagram is based on a pound of fuel of 99 per cent carbon. A supplementary diagram at the top gives the heat brought by the blast for a pound of coke at different temperatures which should be added to the other for the total. This diagram saves much tedious figuring, but must be used with discretion because it takes no account of the presence of any hydrogen which is often produced by the decomposition of moisture from the charge and the oxygen from this moisture oxidizes CO to CO_2 and gives a very distorted impression of the time conditions, unless its source be taken into consideration, because the decomposition of the water absorbs almost as much heat as the corresponding oxidation of CO to CO_2 gives out.

This diagram is based on 0.9 lb. carbon while Fig. 1 is based on 0.85 lb. The discrepancy arose when Fig. 1 was recalculated, both having been based on 0.9 lb. originally; 0.85 is undoubtedly more correct, but Fig. 2 can only be used for rough approximations, and it is hardly worth while to recalculate it merely for the sake of uniformity.

(*To be concluded*)

The mica produced in the United States in 1914 was valued at $328,746.

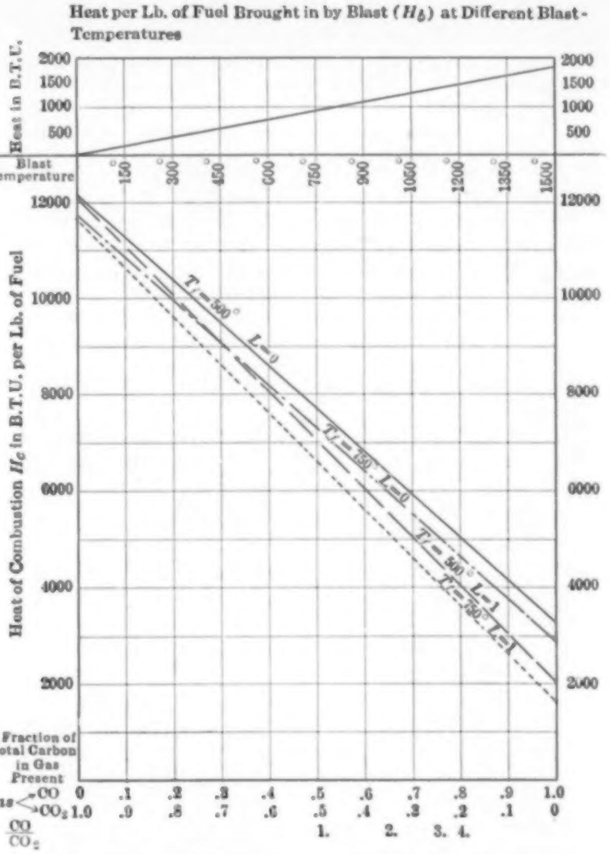

FIG. 2—DIAGRAM SHOWING HEAT IMPARTED TO STOCK BY COMBUSTION IF 1 LB. OF FUEL (90 PER CENT C.) WITH DIFFERENT RATIOS OF CO TO CO_2. TOP TEMPERATURES AND WEIGHTS OF LIMESTONE PER LB. OF FUEL, ALSO (ABOVE) HEAT BROUGHT IN BY BLAST, H_b.

The Stark Rolling Mill Co. of Canton, Ohio, maker of "Toncan" metal has sent us a booklet on "Corrosion, the Cause, the Effect, the Remedy," and also a small booklet entitled "The Sheet Metal Primer."

Testing of Rubber Goods.—Circular No. 38 of the Bureau of Standards, recently issued contains much valuable information on rubber, including the manufacture and physical testing of rubber and the chemistry of rubber.

The **International Oxygen Company** is erecting an oxygen and hydrogen generating plant at Verona, Pa., in the Pittsburgh district, for the accommodation of its customers in that vicinity. This new factory will also serve as a demonstrating installation of the I. O. C. system for inspection by the rapidly increasing number of heads of industries who are deciding to secure the economies resulting from the production, in their own shops, of their required oxygen and hydrogen. Mr. Phillip J. Kroll will be manager of this branch.

Awards for Heat Insulating Material.—The Superior Jury of Awards at the Panama-Pacific International Exposition, San Francisco, has awarded a Grand Prize to the nonpareil heat-insulating materials for general excellence. These materials are manufactured by the Armstrong Cork & Insulation Company, Pittsburgh, Pa., and include nonpareil insulating brick for industrial furnaces, ovens, boiler settings, kilns, etc., nonpareil high-pressure steam covering for high pressure and superheated steam lines, feed-water heaters,, etc., nonpareil cork covering for drinking water systems, brine and ammonia lines and all cold pipes, and nonpareil corkboard for cold storage rooms.

A New Electrolytic Method of Sewage Disposal*

BY J. C. OLSEN

(Concluded from page 739)

EXPERIMENTS USING LIME AND CURRENT

The first series of experiments were carried out for the purpose of ascertaining the effect of the operation of the machine with the addition of lime on the character of the sludge and the effluent. The machine was operated under what may be termed normal conditions. Lime was introduced into the sewage before passing through the machine in quantities equal to 1000 to 1300 lb. per 1,000,000 gal. which is equivalent to 7½ to 9½ grains per gallon. The quantity of lime used was ascertained by the tank being filled with milk of lime of known strength. Titrations were also made of the effluent to ascertain the amount of calcium oxide present in excess over that required to react with the dissolved carbonic acid and the alkalinity of the sewage. The current varied in different tests and ranged from 19.5 to 40.9 amp. This amount of current represented a range of 22.5 to 44.7 coulombs per liter treated (85 to 169 coulombs per gallon). This quantity of electricity will liberate theoretically from 0.00174 to 0.00332 gram per liter or 1.21 to 2.31 c.c.

Samples were taken of the raw sewage designated as "A," of the inflow to the sedimentation tanks designated as "B," and also of the effluent from the sedimentation tank designated as "C." Several samples designated as "D" were also taken of the outfall into the stream at a point several hundred feet distant from the buildings of the plant. These samples were used for the determination of physical appearance, chemical composition, count of bacteria, dissolved oxygen and putrescibility. Samples of sludge were also taken from time to time for examination with reference to putrescibility.

Table I gives the average of a considerable number of analyses of the samples taken at the four points indicated.

TABLE I.—AVERAGE OF THE ANALYSIS OF RAW AND PURIFIED SEWAGE BY ELECTROLYTIC PROCESS

	RAW SEWAGE	PURIFIED SEWAGE		
	Sample *A*	Before Sedimentation Sample *B*	AFTER SEDIMENTATION Sample *C*	Sample *D*
Nitrogen as				
Nitrites	0	0.84	0.13	......
Nitrates	0.02	2.22	3.8	......
Free ammonia	26.5	20.0	13.6	......
Total organic nitrogen	13.8	9.2	5.5	......
Oxygen				
Dissolved	1.62	2.92	3.94	8.35
Per cent of saturation	13.89	26.59	38.38	80.11
Consumed	42.8	36.4	20.7	......
Turbidity	41	27	7.2	......
Color	47	37	19	......
Chlorine	67.6	71.2	70.5	......
Carbon dioxide	21.28	0	0	......
Calcium oxide	0	128.3	80.3	......
Alkalinity	291.7	174.4	80.75	......
Calcium carbonate		294.8	95.3	......
Bacteria count by agar	288,000	46,256.5	471	169

The amount of oxygen liberated by the electric current was relatively small. It ranged from 1.74 to 3.32 mg. per liter of sewage treated which is equal to 1.21 to 2.31 c.c. per liter.

It will be noted that the percentage of nitrates increase from 0.02 in the raw sewage to 2.22 in sample B and to 3.8 in sample C, which indicates oxidation of the nitrogen of the sewage.

The percentage of ammonia decreased from 26.5 to 20 and 13.6 respectively in samples B and C. Undoubtedly, ammonia is lost both by oxidation and volatilization.

The percentage of organic nitrogen decreased from 13.8 in the sewage to 9.2 in sample B. This disappearance of organic nitrogen is, no doubt, partly due to oxidation brought about by the anodic oxygen and partly to precipitation by the lime in the sludge as it was found to contain a considerable amount of nitrogen. The decrease in organic nitrogen continues between B and C which is probably due partly to further precipitation in the sludge and partly to further oxidation. In this manner 60 per cent of the organic nitrogen is removed from the sewage. This large reduction of the organic nitrogen is an important factor in this method of sewage purification.

The oxygen consumed decreases from 42.6 to 26.4 to 20.7 which indicates removal of a large proportion of the dissolved and suspended organic matter.

The per cent of saturation of dissolved oxygen increases from 13.89 to 26.59 and 38.38 which is a total increase of 34.49 per cent.

The bacteria count decreased 84 per cent between A and B, and 99.83 per cent between A and C, which indicates a high degree of purity in the effluent.

A considerable amount of the organic matter is no doubt precipitated with the lime in the sludge and this accounts for some of the changes noted. A considerable number of the bacteria are no doubt removed in this manner. The flocculation and precipitation of the sludge is very rapid after electrolysis and is much more rapid and complete than when lime only is used. This is probably due to the fact that the organic matter in the sewage is present as a colloidal solution which the electrolysis precipitates.

A comparison of the composition of sample C (which was taken after sedimentation, which, in this plant, occupied about 4 hr.) with samples B and A shows that the differences noted between A and B have become more pronounced, that is, nitrates, dissolved oxygen and free lime continue to increase; an exception is found in nitrites which decrease. The remaining constituents decrease in quantity, namely: Ammonia, organic nitrogen, turbidity, color, alkalinity and bacteria. Carbon dioxide naturally remains absent in the presence of free lime. The increase in free lime and decrease in alkalinity is due to the fact that the reaction between the lime and the calcium bicarbonate and other alkaline salts in the sewage requires several hours for its completion and that it is for a time supersaturated with respect to some of the salts formed. The ammonia, no doubt, slowly volatilizes and considerable amounts of atmospheric oxygen are absorbed during sedimentation. The reduction in turbidity and color is, no doubt, due to precipitation.

A number of tests were made on the overflow from the sedimentation tank (sample C) after it had passed through a pipe several hundred feet long and was discharged into a stream flowing from the plant. The time required for this flow was estimated to be about 15 min. The dissolved oxygen rose from about 40 per cent to about 80 per cent while the bacteria count fell from 471 to 169. These results indicate the great purity of the effluent. There could not be any readily oxidizable organic matter in a water which will absorb oxygen so quickly and hold 80 per cent of its saturation value. The drop in bacteria content points to the same conclusion. This was confirmed by allowing samples of this effluent to stand in the laboratory and making bacteria tests on succeeding days. The bacteria count steadily decreased for as long as 9 days.

TABLE II.—STABILITY OF EFFLUENT FROM ELECTROLTYIC PROCESS

As Represented by the Number of Bacteria per C.C. After Plating on Agar

A	B	C	D
	At time of taking sample		
	3	170	
	After standing 24 hours		
	0	21	
	At time of taking sample		
	30,000	400	
	After standing 2 days		
	1,820,000		
	After standing 9 days		
		37	
	At time of taking sample		
550,000			103
	After standing 4 days		
620,000			24

The quantity of lime added varied considerably during the course of the investigation, the average being about 1300 lb. of hydrated lime (72 per cent CaO) per million gallons. This is equal to about 113 parts calcium oxide per million or 6.6 grains per gallon.

A considerable proportion of this lime reacted with the free carbon dioxide in the sewage and then with the calcium bicarbonate, forming calcium carbonate, which constituted a large part of the flocks which settled and formed the sludge. The excess remained as free calcium hydroxide in the effluent. Considerable time was required for the completion of these reactions as was shown by adding lime to a sample of the sewage and titrating with standard acid using phenolphthalein and methyl orange as indicators.

Not only does the reaction seem to be slow but the liquid seems for a time to be supersaturated with calcium carbonate.

Tests were made with no lime at all and a considerable number of proportions up to an excess of nearly 200 parts per million of calcium oxide. When no lime was used and electrolysis only, very little purification of the sewage resulted as shown by bacteria count and clarification and flocculation. Table III gives the result of electrolysis of the sewage with a very small amount of lime as indicated by the alkalinity and absence of calcium oxide. The small amount of nitrates and oxygen consumed and large amount of organic nitrogen and oxygen consumed indicate only slight purification which is also shown by the high bacteria count.

TABLE III.—ANALYSIS OF RAW SEWAGE AND SEWAGE PURIFIED BY ELECTROLYTIC PROCESS

ELECTRICAL DATA

Number of electrolyzing elements in series, 31; amperes, 32; volts, 102

Chemical Analysis

Results given in parts per Million

	Sample *A*	Sample *B*
Temp., degrees C	11	11¼
Nitrogen as		
Nitrites	0.00	1.1
Nitrates	0.06	0.44
Free ammonia	26	22.4
Total organic nitrogen	26	14.4
Oxygen dissolved	2.82	3.5
Per cent of saturation	25.45	31.75
Consumed	74	48
Turbidity	55	35
Color	50	35
Chlorine	64	54
Carbon dioxide	25.0	0
Calcium dioxide	0	0
Alkalinity	291.6	314
Bacteriological Examination		
Bacteria per c.c.		
Agar	584,000	272,000
Gelatine	1,100,000	846,000
Acid-forming bacteria	55,000	45,000
B. Coli	1-100+	1-10+

On the same day using the same sewage a test was made in which the excess lime was forty-three parts per million. Very much better chemical and bacterial purification was obtained as indicated by Table IV.

TABLE IV.—ELECTRICAL DATA

Number of Electrolyzing Elements in Series, 38; Amperes, 27; Volts, 125

Chemical Analysis

Results Given in Parts per Million

	Sample *A*	Sample *B*
Temp., degrees C	11	11¾
Nitrogen as		
Nitrites	0.00	0.24
Nitrates	0.06	4.4
Free ammonia	26	20.0
Total organic nitrogen	20	10.0
Oxygen dissolved	2.82	4.6
Per cent of saturation	25.45	37.90
Consumed	74	55
Turbidity	55	17
Color	50	35
Chlorine	64	75
Carbon dioxide	25.0	0
Calcium oxide	0	43.1
Alkalinity	291.6	101.0
Bacteriological Examination		
Bacteria per c.c.		
Agar	584,000	6,010
Gelatine	1,100,000	140,000
Acid-forming bacteria	55,000	2 000
B. Coli	1-100+	1-1 + 1-10+

A still higher degree of purity was obtained by using an excess of lime equal to 236 parts per million as shown by Table V.

TABLE V.—ELECTRICAL DATA

Mean rate of sewage flow, gals. per day	760,000
Electrolyzing elements in series	38
D. C. average volts	105
D. C. average amperes	22
Anodic oxygen (theoretical) gramme, per liter	0.00208
Anodic oxygen (theoretical) c.c., per liter	1.448

Chemical Analysis

Results Given in Parts per Million

	Sample *A*	Sample *B*	Sample *C*
Temp., degrees C	13	13.5	13.3
Nitrogen as			
Nitrites	0	0.04	0.10
Nitrates	0	2.4	3.6
Free ammonia	26	20	12.0
Total organic nitrogen	14	5.6	0.0
Oxygen dissolved	0.4	2.46	6.11
Per cent of saturation	3.73	23.49	68.01
Consumed	34	20	8
Turbidity	55	2	3
Color	70	25	15
Chlorine	65.5	122	80
Carbon dioxide	24.8	0	0
Calcium oxide	0	236	162
Alkalinity	277.8	....	....
Calcium carbonate	....	239	96
Bacteriological Analysis			
Bacteria per c.c.			
Agar	160,000	0	5
Gelatine	1,000,000	0	170
B. Coli	1-1000+	1-10-	1-1-

This high purity was obtained in spite of the fact that the amount of current used was equivalent to only 1.448 c.c. of anodic oxygen per liter.

The effect of the electric current in increasing flocculation and purification of the sewage is strikingly shown in the following experiment.

At the time of starting the experiment the machine was running normally and had been so for several days, current, lime and agitation being employed. The effluent was clear and excellent in every respect. The lime was added at the far or outlet end of the machine.

Sewage flow, 755,000 gals. per day.

Current, 40 amp., 120 volts.

About 1000 lb. of hydrated lime (72.87 per cent calcium oxide) being used per day. This is equivalent to 965 lb. of lime per million gallons, or 9 grains of lime per gallon.

Under these normal conditions the appearance of the liquid in the flume was good, with large flocks, which

settled rapidly in the Imhoff tube, leaving a clear liquid above. The Imhoff reading was 20 c.c. (All Imhoff tube readings were made after ten minutes' sedimentation.) The final effluent was nearly water-like in appearance, odorless and there was no odor in the tank-house or plant generally.

1.50 p. m.—The current was cut off, and the agitation by means of the paddles stopped. The flow of milk of lime into the sewage at the outlet end of the machine was continued.

1.55 p. m.—The liquid in the flume had become very noticeably darker, with much smaller flocks.

2 p. m.—The liquid in the flume was decidedly dark, the flocks small. Imhoff tube reading, 3 c.c.

2.02 p. m.—The current was turned on again, other conditions remaining the same.

2.07 p. m.—The liquid in the flume was lighter and the flock better.

2.12 p. m.—The liquid in the flume same as at 2.07 p. m. A half gallon was lighter in color than a similar sample at 2. Imhoff tube reading, 10 c.c.

2.17 p. m.—The point of lime feed was changed, so as to allow the lime to be admitted at the suction end of the pump, thereby being mixed with the sewage which then passed through the machine. The current was turned off, and there was no agitation by means of the paddles.

2.22 p. m.—The liquid in the flume was darker, and the flocks smaller.

2.31 p. m.—The liquid in the flume still dark, the flocks small and poor. In the Imhoff tube, the flocks appeared small and poor. Imhoff tube reading 0.75 c.c.

2.32 p. m.—The electrolyzing current was again turned on and agitation by means of the paddles started. The lime continued to be added through the pump.

2.42 p. m.—Color dark in the flume, but flocculation better.

2.46 p. m.—Imhoff tube reading, 16 c.c., but the sediment was dark in color.

2.47 p. m.—The electrolyzing paddles and current continued in operation but the lime was introduced at the outlet end of the machine. This reproduced the conditions found at 1.30 p. m.

2.52 p.m.—The liquid in the flume became lighter, with a heavy flock, quickly settling. The deposit in the Imhoff tube was heavy, and settled rapidly.

This experiment, together with the one previously made, showed that electrolyzation of the sewage serves to produce a lighter colored effluent, and materially increases the amount of flocculation and precipitation of the suspended matter in the sewage, probably because the current tends to agglutinate the colloidal particles.

The chemical analyses of the effluent show that when the current and lime are both used the effluent is more free from nitrogenous organic matter, 60 per cent of the total organic nitrogen being removed; whereas when the current is not used only 11 per cent of the nitrogenous organic matter is removed and the bacteria multiply in the effluent, probably because of the greater abundance of food.

In order to secure information as to the effect of lime only on the Elmhurst sewage, a number of experiments were carried out in which conditions were identical with the electrolytic treatment except the electrolyzation. Table VI gives the average of these results.

It will be noted on reference to the results given in Table VI that the percentage of nitrates in sample B is very small and differs in this respect from the corresponding average in the electrolytic treatment (Table I). In sample C (Table VI), however, the percentage

TABLE VI.—AVERAGE OF THE ANALYSES OF RAW AND PURIFIED SEWAGE WITH LIME ONLY, WITHOUT ELECTROLYZATION

	Sample *A*	Sample *B*	Sample *C*
Nitrogen as			
Nitrites	....	0	0.32
Nitrates	....	0.02	3.6
Free ammonia	22	15.8	10.0
Total organic nitrogen	3.6	3.4	3.2
Oxygen dissolved	2.92	3.78	4.80
Per cent of saturation	27.75	36.25	46.07
Consumed	....	23.7	21.0
Turbidity	50	33	10
Color	....	45	14
Carbon dioxide	24.62	0	0
Calcium oxide	0	19.6	9.52
Alkalinity	271.8	299.6	112.1
Calcium carbonate	0	274.2	86.61
Total solids	....	....	134
Bacteria per c.c.			
Agar	187,000	54,120	5430

of nitrates is 3.6 which is very nearly equal to the corresponding average in Table I.

The organic nitrogen decreases from 3.6 to 3.4, which is a reduction of only 6 per cent compared with 40 per cent in the table of electrolytic treatment (Table I). Between B and C there is a further decrease of only 6 per cent compared with 20 per cent in the table of electrolytic treatment. This indicates an important difference between these methods of treatment and shows that the removal of organic nitrogen is comparatively slight in the case of treatment with lime alone.

The total increase in percentage of dissolved oxygen between samples A and C is 18.32 per cent as compared with 24.49 in the case of the electrolytic treatment. The decrease in bacteria count between A and C is 9.7 per cent as compared with decreases of 84 and 99.83 per cent respectively in the case of the electrolytic treatment.

The most striking evidence of the very marked purifying effect of the treatment with lime and electrolyzation is obtained by noting the change in bacteria content on allowing samples to stand for one or more days. These results are given in Table II.

TABLE VII.—STABILITY OF SEWAGE AND EFFLUENT WHEN USING LIME ONLY
Represented by the Number of Bacteria per C.C. Incubated on Agar

A	*B*	*C*	*D*
	At time of taking sample		
140,000	51,000		
	After standing 8 days		
120,000	77,000		
	At time of taking sample		
		10,000	
	After standing 3 days		
		1,540,000	
	At time of taking sample		
124,000		10,000	7,400
	After standing 1 day		
1,860,000		4,032,000	750,000
	After standing 2 days		
520,000		2,670,000	591,000
	After standing 3 days		
820,000		338,000	105,000

It will be noticed that the bacteria increase very rapidly after treatment with lime only. In this respect there is a very striking difference when samples which have been subjected to electrolysis and lime are allowed to stand. In this case there is a very marked decrease in the already low bacteria count. An exception to this condition is sometimes found in sample B which has not passed through the sedimentation tank.

The difference between the two processes is also very noticeable on an inspection of sewage disposal plants operated by the two methods. At plants using lime only the effluent is dark colored, quite high in bacteria and far from pure. Both effluent and sludge produce considerable odor so that the disposal works are a nuisance to nearby neighbors while the effluent pollutes streams into which it is discharged.

On the other hand the Elmhurst plant during the time it has been operating on 750,000 gal. of sewage has been entirely free from unpleasant odor, the effluent being clear and free from color and could be discharged

into any stream without causing any pollution whatever.

It is common, when discussing electrolytic processes for sewage treatment, to speak of the liberation of chlorine, or the formation of a hypochlorite by the action of the electric current upon the common salt present in the sewage, and then to credit such substances with much of the beneficial action claimed for the process. Careful chemical examination made at various times of the effluent of the electrolytic machine at Elmhurst failed to give any reaction whatever for free chlorine or hypochlorites. The conclusion seems warranted that neither of these substances is present in the sewage electrolyzed by the process.

In order to confirm this conclusion, a study was made of the effect of adding bleaching powder to sewage. A visit was first made to Providence, R. I., where lime and bleaching powder have been used for a great many years in the treatment of the municipal sewage. At the Providence plant 144 lb. of bleaching powder and 400 lb. of lime are used per million gallons of sewage treated. The amount of bleaching powder added is 17.3 parts per million, the available chlorine being 5.7 parts per million. This is equivalent to 1.3 mg. of oxygen per liter which is about the amount of anodic oxygen produced by the electric current in the Landreth machine. At Providence the treated sewage is allowed to settle in sedimentation tanks.

The effluent as discharged into the river contains from 20 to 50 per cent of dissolved oxygen. The dissolved oxygen in the river is generally zero. Sixty-five per cent of the total bacteria were removed, as counted on litmus agar, incubated at 37½ deg. The B. Coli removed amounted to 97 per cent. The effluent is putrescent and quite impure, but the use of the process is justified by the polluted condition of the river, so that the requirements for purity are very low. The statement was made that if it should become necessary to secure a higher state of purity, a more efficient process of sewage disposal than the one now in use must be installed.

Laboratory tests were made with Elmhurst sewage. Bleaching powder and lime were added in the proportions used at Providence, namely, 144 lb. of the former and 400 lb. of the latter. The odor of hypochlorites was very noticeable and persisted for about 24 hr. No odor of this kind had ever been detected on the effluent at Elmhurst. The sewage also remained turbid and did not settle clear even after several days' standing.

The bacteria count was reduced about 97 per cent, but on standing 21 hr. the bacteria count had risen and was higher than that of the raw sewage. The odor of chlorine had also disappeared, showing that the bleaching powder prevented the growth of bacteria but did not remove the organic matter and produce a stable effluent. The results are given in Table VIII.

Another test was made in which twice as much lime and bleaching powder was added as used at Providence. This would give chlorine equivalent to about 2.6 mg. of anodic oxygen per liter, which, with the amount of lime used, would give a very clear and stable effluent by the Elmhurst electrolytic process. In this experiment the chlorine odor persisted for 24 hr., the bacteria count was very low on the second day but after standing for three days, the bacteria count on agar was 5,550,000 and the liquid had a putrid odor. The results are given in Table IX.

In another test the untreated sewage as well as the treated sewage was allowed to stand and was plated. After five days the bacteria count was 4,460,000 in the sewage treated with bleaching powder. The results are given in Table X.

TABLE VIII—BACTERIA PER C.C. IN RAW SEWAGE AND SEWAGE TREATED WITH LIME, AND BLEACHING POWDER

Bleaching Powder Added, 144 Lb. Per Million Gal. Lime Added, 400 Lb. Per Million Gal.

	Raw Sewage	Treated Sewage	Odor
After standing 1 hour			
Agar	62,000	1,830	Chlorine
Gelatine	520,000	22,000	
After standing 21 hours			
Agar	....	907,000	Quite putrid
Gelatine	....	2,430,000	
After standing 3 days			
Agar	....	1,800,000	Very putrid
Gelatine	....	2,000,000	

TABLE IX.—BCATERIA PER C.C. IN RAW SEWAGE AND SEWAGE TREATED WITH LIME AND BLEACHING POWDER

Bleaching Powder Added, 288 Lb. Per Million Gal. Lime Added, 800 Lb. Per Million Gal.

	Raw Sewage	Treated Sewage	Odor
After standing 1 hour			
Agar	62,000	200	Chlorine
Gelatine	520,000	4,200	
After standing 24 hours			
Agar	....	200	Slight Chlorine
Gelatine	....	160	
After standing 3 days			
Agar	....	5,500,000	Putrid
Gelatine	Plates entirely liquefied		

TABLE X.—BACTERIA PER C.C. IN RAW SEWAGE AND SEWAGE TREATED WITH LIME AND BLEACHING POWDER

Bleaching Powder Added, 235 Lb. of 23 Per Cent Chlorine Per Million Gallons Which is Equivalent to 63 Lb. of Chlorine Per Million Gallons or 6.5 Parts Chlorine Per Million Gallons. Lime Added ,1079 Lb. Calcium Oxide Per Million Gallons

	Raw Sewage	Treated Sewage
After standing 3 hours		
Agar	580,000	130
B. Coli	....	0
After standing 24 hours		
Agar	....	230
B. Coli	....	0
After standing 48 hours		
Agar	300,000	50
B. Coli	....	0
After standing 3 days		
Agar	610,000	40
After standing 4 days		
Agar	620,000	....
After standing 5 days		
Agar	....	4,460,000
B. Coli	....	0

It is apparent from these results that bleaching powder has a very marked destructive action on bacteria but that there is very little action on the dissolved organic matter. It is, no doubt, very effective in purifying a contaminated water but is not a suitable reagent for the oxidation of the large amount of organic matter present in a sewage so as to produce a stable effluent.

The sludge produced at Elmhurst amounted to about 1500 lb. of the dried material. The moist press-cake contained about 69 per cent of water. It contained about 0.59 per cent ammonia equal to 3.7 per cent proteid and 0.54 per cent calcium phosphate, the remainder being mostly calcium carbonate. While moist the press-cake has a slight odor of ammonia which becomes more

intense if the sludge is kept in a closed vessel. Putrescibility tests showed it to be stable for more than four days. When allowed to dry, it becomes entirely odorless. A number of methods of disposal of this sludge seem to be feasible. It can be used as a filler on low ground as it will not produce a nuisance. If used in this manner, filter pressing would be unnecessary if vacant ground near the plant is available as the liquid sludge could be pumped out. The sludge would also find some use as a fertilizer. It could also be burned so as to recover the lime.

COST OF OPERATION

A careful study was made of the cost of operation of this process of sewage disposal. The actual cost of operation of the Elmhurst plant cannot be taken as the normal operating cost of a plant of this kind because the plant was designed and built for an entirely different process and because during the period of the test it was not continuously operated on a normal basis. The operating cost will include the following items: electric current and power, lime, labor, maintenance supplies, etc., and sludge.

ELECTRIC CURRENT AND POWER

From the study made of the process a fairly accurate estimate may be made of the minimum amount of electric energy required for the electrolyzation of a million gallons of sewage and this was found to be 85 kw.-hr. The cost of electric current varies greatly in different localities. At 2 cents this item would be $1.70 per million gallons.

Electric energy was also used to rotate the paddles and produce agitation in the machine. This required 60 kw.-hr. per million gallons, and at 2 cents would be $1.20.

A small electric motor was used to operate the agitator in the lime vat and consumed 16 kw.-hr. which at 2 cents would be $0.32.

LIME

It was possible to make a very close estimate of the amount of lime required which was about 950 lb. of calcium oxide or approximately ½ ton of commercial lime. Under favorable conditions lime can be obtained in carload lots at about $6 per ton, making this item of cost $3 per million gallons.

LABOR AND SUPERVISION

It has been very difficult to estimate the cost of labor and supervision for a plant of this kind from the experience at the Elmhurst plant. This element of cost will decrease very rapidly with the size of the plant and will also vary with the method of sludge removal employed. For a 10,000,000-gal. plant $3 per million gallons would seem reasonable.

MAINTENANCE AND SUPPLIES

The principal item of expense under this heading will be the renewal of the iron electrode plates. This and other items would be covered by an allowance of $1 per million gallons.

SLUDGE DISPOSAL

The cost of sludge disposal would vary with local conditions and especially with the methods of disposal which may be utilized. The simplest and cheapest method of disposal consists in pumping the liquid sludge on the land adjoining the plant which must be filled in. The cost of pumping the sludge obtained from a million gallons of sewage is very small. If the sludge is used for fertilizer it must be filter-pressed. This will cost about $2.50 per million gallons of sewage. In a farming section the filter-pressed sludge will be removed by the farmers. Where this is not feasible the sludge must be disposed of by removal and dumping on waste land or at sea. Where this is necessary the cost may be considered $2.50 per million gallons of sewage.

TABLE XI.—ESTIMATED COST OF SEWAGE DISPOSAL BY ELECTROLYTIC PROCESS FOR A TEN-MILLION-GALLON PLANT

Lime, 5 tons at $6.00 per ton	$30.00
Electricity for electrolyzation at 2c	17.00
Electricity for agitation at 2c	14.20
Labor and supervision	30.00
Maintenance and supplies	10.00
Sludge disposal	25.00
	$126.20
Cost per million gallons	$12.62

ADVANTAGES OF THE METHOD

The advantages of the method may be briefly stated as follows:

(a) The effluent is of a very high degree of purity and may be discharged into any water course without creating any nuisance whatever or injury to fish or oysters.

(b) No odor or other nuisance is produced by the plant so that it may be located at any sewer outlet or other convenient point.

(c) The amount of space required for the plant is very small. This very much reduces the cost of the necessary site and gives a much more general choice of location.

(d) On account of the freedom from nuisance and small space required, plants may be located at convenient points and the construction of costly trunk sewers obviated.

(e) The initial cost of installation is low as compared with other processes.

The Chemical Engineering of the Hardwood Distillation Industry*

BY JAMES R. WITHROW

It would require more time than we have at our disposal to go into the details of the chemical engineering of the hardwood distillation industry. General features will be pointed out, just sufficient to give a broad survey of the problems involved in plant operation.

The industrial demand which the hardwood distillation industry meets is sufficiently indicated by the mere mention of acetic acid, methyl alcohol, acetone, chloroform and formaldehyde, without burdening you with statistics of their production, consumption, exportation and importation. The number of industries and objectives in the arts which benefit by the availibility of these substances is surprisingly great, though not all of these substances are exclusively the products of this industry.

Development

The development of the industry appears to have been very simple. From the earliest times charcoal appears to have been used in the arts and especially in metallurgy.

That liquid products could be formed during the charcoal production was very early observed. Uses were gradually found for these products, and in course of time a demand was created for them, with the result that wood carbonization was largely changed in method so as to improve the yield of the desired by-products.

The historical development of this industry is one of the most interesting in the annals of industrial chemistry, because it illustrates so well the battledore and

*A paper presented in the symposium on wood distillation at the Seattle meeting of the American Chemical Society.

shuttlecock fortune of so many of these industries. So often the by-product of to-day becomes the main product of to-morrow, and the new industry, which appears the worst competitive enemy of one industry, becomes the greatest blessing of the old industry in the next decade.

The liquid products accompanying charcoal production are said to have been recovered by the ancient Egyptians and utilized by them in embalming the dead. Pliny mentions their recovery in Syria and Theophrastus in Macedonia. As chemical knowledge in those days appears to have been very limited, and engineering skill as much so, the recovery of liquid products must have been trifling, and it was many centuries before chemical knowledge made possible and the arts demanded intelligent development.

Notwithstanding the later development of the engineering as well as chemical side of the industry the essential features of primitive wood carbonization have come down practically unaltered to the present day. This primitive charcoal burning is still practised wherever wood is plentiful—in Russia, Scandinavia, Austria-Hungary, Germany (Westphalia and the Harz), New Jersey, Maryland, etc.

In spite of various uses to which they were put in early times no real appreciation of the value of the liquid substances known to be formed during carbonization of wood came until the dawn of modern chemical investigation. Lack of sufficient fundamental chemical knowledge was largely responsible for this. For instance, as early as 1658 Glauber identified the so-called "burnt-wood acid" with acetic acid, yet not until 1802 was it identified with the acetic acid of fermentation by Thenard. In 1661 Robert Boyle discovered wood-spirit in wood distillate, yet not until 1812 did Taylor notice its analogy to grain alcohol.

The true character of this "spirit" was only established after a series of investigations by Colin, Dobereiner, Gmelin, Liebig, Sweitzer, and especially Dumas and Pèligot, ending about 1835. As a result of these investigations, together with those on the composition of the wood tar and wood gas, there came an increased effort to recover such of these by-products as were suitable for use in the arts in general, as well as in the organic chemical industries that were at this time struggling for a footing upon the investigations of the great masters of our science. The first step in this revolution was the use of by-product kilns and retorts in place of the old sod-covered pits or heaps, for carbonization. It would seem that from this point, at least, the development of the industry should have been consistent and perhaps rapid, but this was not the case.

Apparently the first product to have been systematically recovered was the wood gas. This was first used in England for illuminating purposes somewhat prior to the chemical developments just mentioned. The honor, however, for the exhaustive investigation of the illuminating, heating and power value of this gas belong to the Frenchman Phillip Lebon.

The weakly illuminating wood gas was soon outclassed, however, by the development of coal gas production, and the whole hardwood distillation industry had a precarious existence during a large part of the last century, even in spite of the fact that a satisfactory method of purifying the crude acetic acid had been devised as early as 1824 by Mollerat and Jasmeyer.

The products of the destructive distillation of coal, such as coke, illuminating gas, tar and tar distillates, were sharp competitors of the wood products. Yet when the wood industry seemed about to be relegated to the primitive woods, the sudden development of the coal-tar color industry started a demand for acetic acid, methyl alcohol and acetone which has since been augmented by the demand for the same products in the production of celluloid and smokeless powder, as well as many synthetic organic substances used in pharmacy and the arts.

The demand for methyl alcohol within a few years after Perkins' discovery of aniline dyes became so great that the price was enormous. It is not surprising, therefore, that at that time in England wood was distilled with the sole object of getting wood alcohol. A like situation is said to have arisen at one time in benzol manufacture, coal having been for a while distilled with the sole object of obtaining benzol for aniline production.

These general statements regarding the development of the industry bring us to the present situation where we recover mainly the primary products—wood gas, raw liquor (pyroligneous acid), tars and oils, and charcoal. It should be noticed in passing that while most engineering skill is a matter of quite recent development, and chemical engineering is perhaps the most recently developed phase of engineering, yet it has been able reasonably to keep pace with chemical development in this industry at least, and this may be due largely to the fact that the development of engineering methods, and the understanding and fabrication of engineering materials of construction developed along with the science of chemistry and are somewhat dependent upon it.

The Problem of the Industry

Broadly speaking, the problem of the hardwood distillation industry is the complete utilization of the weight of the original wood as far as this is possible by economical chemical engineering manipulation for the production of the products which it will yield of main industrial use or value, i.e., charcoal, acetic acid and methyl alcohol.

Economical chemical engineering involves the use and sequence of such operations as will give the maximum financial return, per unit of raw material consumed, consistent with a proper balance between low cost of operation, low initial cost of plant and highest speed of turnover (processing raw material).

When wood is heated sufficiently in the atmosphere it tends to burn, of course, to residual ash, steam and carbon dioxide, for the most part. If the air is partially excluded we obtain residual charcoal and volatile products varying widely in composition, depending upon the extent of air exclusion, from the condition of almost complete combustion of volatile products to practically entire elimination of combustion or atmospheric oxidation when air is excluded as completely as possible. The problem of the industry may be met therefore by heating the wood sufficiently to carbonize it, and in such a way as to eliminate as far as possible any atmospheric oxidation of the volatile products and, at the same time handle the distillates in such a way as to minimize refining or purification difficulties.

Modern chemical engineering skill has met the conditions of reasonably efficient solution of the problem with fair success, as is shown by the extent of the industry, and without doubt will advance still further.

Every problem, however large, is merely a series of smaller sub-problems, and each of these in turn is often resolvable into still other problems. In studying the problem of any chemical industry it is natural to divide it as far as possible into

1. The nature of the demand or market for the products or objectives of the industry.
2. The chemistry involved.
3. The operations or engineering involved.

The chemistry of the hardwood distillation industry

finds its basis in the phenomena attending destructive distillation. Much more should be known about destructive distillation than *is* known. Our concern at this time, however, is with the engineering problems involved in the utilization of this chemistry. Suffice it to say in the matter of the chemistry involved, that the products of heating the wood, as is usually the case in destructive distillation, are gaseous, liquid (condensate) and solid (residual charcoal). The gas as a whole is combustible. The liquid is acid, and in two (or three) nearly non-miscible phases—tar (and oil) and dilute alcoholic acetic acid, with dissolved tar and other substances.

Chemical Engineering Operations

The engineering operations of the industry may be divided in general into four divisions.

1. Those concerned with the preliminary handling of the raw material.
2. Those concerned in the destructive distillation proper or so-called primary distillation.
3. Those concerned with the treatment of the liquid distillate or secondary distillation.
4. Those concerned with refining operations, and derived product production. The latter is not generally connected with what is known as the crude hardwood industry, and will therefore be indicated in great brevity.

The engineering operations which group themselves in these four divisions, and which are necessary for the accomplishing of the objects of the industry, are:

I.—*Preliminary Handling of Wood.*

1. Harvesting the timber—cutting, splitting.
2. Seasoning, transportation and storage.

II.—*Preliminary Distillation.*

1. Loading oven cars.
2. Charging and sealing ovens.
3. Firing ovens (distillation).
4. Condensation and fuel gas recovery.
5. Pulling ovens (discharging hot charcoal cars).
6. Cooling charcoal.
7. Pulling charcoal coolers.
8. Aging charcoal.
9. Screening charcoal—*charcoal for the market.*

III.—*Secondary Distillation (of Condensate Obtained in II, 4).*

1. Settling "raw liquor" (condensate II, 4).
2. Separation of tar (and oil) from "raw liquor" (continuous decantation).
3. Redistillation of settled tar (for further recovery of "raw liquor"). Copper or wooden stills.
4. Condensation of acid distillate (oil added to "boiled tar," water added to original "raw liquor"—condensate II, 4).
5. Redistillation of settled "raw liquor" (for further tarry-bodies elimination). Continuous copper stills.
6. Condensation of "boiled liquor."
7. "Mixing boiled liquor" with lime (neutralization).
8. Distillation of neutralized "boiled liquor" in lime-lee still (iron).
9. Condensation of weak alcohol-acetone.
10. Settling or filtering lime-lee still residue (aqueous calcium acetate).
11. Evaporation and crystallization of lime-lee residues.
12. Drying crystallized acetate of lime (sacking, weighing, analysis). *Gray acetate of lime (80 per cent) for the market.*
13. Redistillation of weak alcohol-acetone for oil separation and concentration (Burcey pans, fractionation).
14. Condensation of alcohol-acetone in fractions. *Crude 82 per cent alcohol-acetone for market or refinery.*

IV.—*Refining and Derived Product Manufacture.*

Alcohol.—1. Chemical treatment of crude alcohol (NaOH or H_2SO_4).
2. Distillation and condensation for elimination of chemicals, etc.
3. Fractional distillation (column still).
4. Condensation with "heads and tails" elimination. *Refined methyl alcohol and acetone-alcohol for market.*

Gray Acetate.—1. Distillation with sulphuric acid or (HCl).
2. Dust elimination from vapors.
3. Condensation of acetic acid (commercial).
4. Refining by redistillation and fractionation after chemical or electrical treatment. *Refined and concentrated acetic acid for market.*

Gray Acetate.—1. Destructive distillation.
2. Dust elimination from vapors.
3. Condensation of crude acetone and oils.
4. Separation of oils from acetone.
5. Chemical treatment (alkali) for acid elimination.
6. Redistillation for "white oil" elimination.
7. Fractional distillation of acetone.
8. Condensation. *Acetone for the market.*

Each and every one of these operations calls for its own special form of apparatus or construction, and modifies to a varying extent the design and operation of the plant. They are the essential operations or chemical engineering proper which must be carried out to secure the results obtained in first class practice. There has been indicated also, in a limited way, how some of these operations must be carried out. Sufficient preliminary discussion of the development of the industry has been given to illustrate the connection which appears to have existed between the development of both chemical knowledge and engineering skill and the growth and development of this industry.

In concluding I must express my indebtedness to Mr. Edward H. French, to whom I owe my first opportunity, a number of years ago, of working upon the problems of this industry upon which he was himself engaged.

Ohio State University,
Columbus, Ohio.

More Engineering English

From the October *Bulletin of The Engineering Society* of Buffalo:

"Mr. H——, having made a vocation of this practical art of manufacture, will undoubtedly be able to learn us a way to stronger build our organization . . ."

Evidently there is room for another hyphenated profession—that of Literary-Engineer.

Magnetic Separator Pulleys.—As illustrative of the varied applications of their magnetic separator pulleys the Cutler-Hammer Clutch Co., Milwaukee, Wis., has issued Bulletin 25 describing its many uses, method of installation and principles of operation.

Molybdenite.—At the molybdenite mine at Dacre, Ontario, Canada, which has been worked for the past year and a half and which is controlled by Willam J. Spain, 417 Fifth Avenue, New York, a concentrating plant is now being installed and is expected to be in running order by January, 1916. The ore is a very high-grade molybdenum sulphide. The great interest which is being taken at present in molybdenum is due to the fact that molybdenum has properties very similar to tungsten and can be used as a substitute for tungsten in various applications, especially in special steel manufacture. This is of considerable importance in view of the present high price of tungsten.

The Relation of Chemistry and Mechanical Manipulation to the Evolution of the Glass Industry*

BY ROBERT L. FRINK

To do more than touch upon the generalities of the subject, would evolve a great amount of data, and lengthy explanations. It would necessitate to present for criticism or ridicule many of the mooted questions which many now consider as fixed and well determined from a practical standpoint, while from a chemical standpoint they must be considered irrational. Therefore I must and will endeavor to deal with those generalities only which show the progress of the glass industry from a mechanical and chemical standpoint, and I will touch only upon those specific conditions and materials that go to make up success or failure in handling, forming and making of glass articles by the processes of to-day.

If one has access to the information which is upon record in the Patent Office or in memoirs or can be obtained from personal conversation with some of the older men in the industry, it is astounding to learn that many of our advanced mechanical appliances and means for manipulating glass, were conceived, and in some instances exploited, fifty, sixty or more years ago There is perhaps no instance in the annals of the Patent Office wherein the understanding of the true properties and requirements of glass are set forth in any more definite manner than in the old French patent of Loup, of 1854, wherein Loup has conceived and designed a mechanical device for the producing of cylinders of glass by means of what is at present known as a "bait member." This is lowered into a body of molten glass, withdrawn therefrom, air pressure is supplied within the cylinder thus formed, and then a cylinder is progressively drawn from the molten body. However, Loup recites that the temperature, the specific heat, the expansion and contraction of the glass, and the air within the cylinder are all factors in producing a uniform cylinder of glass, and that composition affects all these factors.

Later Opperman attempted to produce the same result by a considerably different process, using purely mechanical devices throughout to obtain the drawing of the cylinder, the introduction of the air thereto, and the control of the pressure of the air therein. He, however, makes no specific reference to any of the physical properties of the glass, or their effect upon the success or failure of his apparatus to produce the required result.

Later Sievert, Lubbers, George and Shortle, and others, besides myself, attempted the production of glass in this manner, and at a still later date the American Window Glass Company in 1904 took up Lubbers' conception, a somewhat crude but nevertheless demonstrative device, and exploited same, introducing at Alexandria, Indiana, a full equipment for the production of window glass. This process comprised the lowering into a bath of glass a pipe similar to the ordinary glassblower's pipe, although larger and heavier, withdrawing this pipe from the bath of glass, introducing the air through the pipe member, and controlling the air pressure in a manner as to blow out and form a cylinder of glass.

The preliminary results obtained in this operation appeared to be perfect, so far as the forming of the cylinder was concerned, and the officers of this company had so much confidence in the results that they installed these machines in a number of their plants. Certain modifications and improvements were added whereby it was deemed that the cost of manufacture, maintenance and upkeep would be reduced below that of the original plant. It was found, however, that under practical operating conditions there were other fatcors, hidden ones, which greatly affected the amount of glass which could be delivered to the warehouse, and that it was quite a different proposition to make cylinders of glass in quantities, sizes and thickness, and cut them into lengths, flatten them, and again cut them into sheets the quality and perfectness of which would permit of their being placed upon the market. A cylinder might be made that was perfect and drawn perhaps to a length of 20 ft. or more, but when it was attempted to lower this cylinder, cut it up into lengths or flatten it into flat panes of glass, breakage would occur, and this breakage sometimes would be in excess of 80 per cent of the total production. At times it amounted to as much as 90 per cent of the possible production.

The cause of this breakage seemed entirely obscure to the most practical and successful glassworkers and glassmakers, and for a time it seemed as though the prediction of old glassworkers was about to prove true, namely that "the devil resides in glass and man can not take him out." However, as is usually the case when the practical "rule-of-thumb" man meets unknown difficulties, he turns to science for assistance, and by the combination of logical theory with methodical practice the problem is solved.

It was found that these breakages occurred as a result of the differences which existed in the composition of the glass comprising an individual cylinder, and that the operators were seriously hampered by the lack of information concerning the correct temperatures to be used, concerning the difference of expansion and contraction between the metal forming the bait and the glass, concerning the effect of the chemical composition of the glass and the chemical reactions caused by the conditions of operation of the furnaces, namely, temperature, fire conditions, quantity of material melted or moved through the furnace, and the action of combustion gases.

After lengthy investigations had been conducted and these conditions had been determined, and the chemical and physical properties of glass had also been investigated, many of the early difficulties were overcome, and the process of mechanically forming glass cylinders became clear and much simplified, and to-day stands as one of the foremost successful inventions of the age, although this very same process and the principles involved therein were conceived and attempted by Loup in 1854. Loup might have been successful in accomplishing what is accomplished to-day had he been in a position to command the results of research and the benefit of the progress which has been attained in our present-day chemical industries, and had he been able to get the financial assistance, whereby he could have worked out the conceptions set forth in the preamble of his patent application. For therein he hinted at or directly stated the primary factors which govern the sequence and method of producing glass cylinders. All attempts prior to 1904 unquestionably failed because of the lack of knowledge of the material that the experimenters were working with, its mechanical constitution and means of controlling such constitution.

In 1882 Clark, and subsequently Schulze-Berge, Sievert, Dolan, George and Shortle, Fourcault, Colburn and I attempted making glass in sheet form by withdrawing a sheet of glass from a bath of molten glass, or by flowing a stream of metal in sheet form over a weir or dam-like aperture, or by forcing it through an aperture. Even Mr. Edison has attempted the production of sheet glass in this form, and to this day it is

*An address made before the First National Exposition of Chemical Industries in New York City on Sept. 25, 1915.

still being attempted. Vast sums of money have been expended in an endeavor to produce a sheet of glass uniform in thickness and having plane surfaces, but all attempts so far have been commercial failures, and I firmly believe for no other cause than our lack of knowledge concerning chemical and physical control of those factors which co-operate to produce a homogeneous glass.

In 1903 I produced sheets of glass from 0.003 in. to 3/8 in. in thickness, which appeared to be perfect when entering the annealing oven and coming from the forming device, or before they had cooled to a temperature of less than 250 deg. C. But below this temperature they would begin to warp and get distorted in a manner which made them entirely unfit for commercial use. It has been said that there is one sheet machine on which there has been over a million dollars expended in an endeavor to produce a sheet of glass directly from the bath of molten glass, but failure has as yet been the only result, due entirely to "warping" as it is called, and to lack of homogeneity.

Other factors which have been a great bane to the sheet glass manufacturers are the mottled appearance of the glass and the difficulty in producing glass which can be placed into windows and retain its surface lustre or be free from "fading" as it is termed. This fading is in fact a disintegration or delinquence of the surface due to adsorption or the chemical effects of gases or moisture coming in contact with the surface of the glass and combining with the constituents thereof.

In the making of pressed ware, i. e., tumblers, jelly dishes, cake dishes, punch bowls, etc., much difficulty is experienced in obtaining a glass which can be manipulated in sufficient quantities in an iron mold and pressed out in the desired form, so as to obtain the tone configuration of the mold without showing imperfections. In recent years, since the advent of the pressing and blowing machines for the making of bottles, milk jars, table ware, fruit jars, etc., many of the difficulties before mentioned have presented themselves. That is to say, the machine may be of good design and produce ware of commercially perfect shape from the molds, but in subsequent operations to which this ware is subjected, many sources of loss occur. In the making of goblets, shades, etc., after the article has been formed from the molten mass, and either cooled to atmospheric temperature or reduced in temperature to 100 or more degrees below the solidifying point, it must be again subjected to the impinging heat of a flame to round the edges or permit a reshaping of the piece, and this treatment will often cause the ware to fly to pieces. Or perhaps the ware may be subjected to a grinding operation, and the abrasive effect of the wheel or stone or perhaps the rise of temperature occasioned by the grinding will produce breakage. In the case of milk jars, fruit jars, or bottles subjected to sterilizing or pasteurizing operations, the sudden heating or cooling of the same would cause them to break and possibly incur the loss of the liquid placed in them, and all of these conditions are due to heterogeneity.

Perhaps one of the greatest banes of the electric lamp manufacturer is the breakage of his stems, or the joints between the stem and the bulb, or possibly the imperfect sealing of the leading-in wires. Again another defect which he has to contend with and which is due to lack of chemical control, is the smutting of the bulbs, this being again a chemical effect upon the surface of the glass caused by the contact of gases which attack the glass and reduce the lead therein.

I have gone to some length in enumerating some of the principal causes of loss in production and lack of satisfaction as to quality in the different cruder and grosser branches of the glass industry, in which it has been thought inadvisable, or at least unprofitable, to employ a scientist or chemist for the purpose of investigating and determining the causes of these losses. This is due, to a great extent, to the fact that the glass manufacturers and the men in control of the glass factories are, in the majority of cases, men who have grown up in the business and have been compelled to devote their time to the practical problems as they saw them and had no time to investigate the possibilities of scientific research.

As a matter of fact, there are a great many so-called first-class glassmakers, and men who are responsible for large productions and finest quality of ware, whose knowledge of the constitution of glass begins and ends the moment when the material enters the furnace, and as a matter of fact many of them still believe that glass is composed of sand which has been reduced to a molten state by being placed in a mixture with such ingredients as lime, soda, potash, feldspar, fluorspar, cryolite, antimony, zinc oxide, borax, or whatever else their batch formula may call for, and that after it has been subjected to fire all of the ingredients with the exception of sand go up the stack. It is only the more progressive individuals who have studied this matter, who have benefited by research, and who have any true conception of the actual composition of the glasses that they are making. However, even they, in many instances, have no true knowledge as to the properties given to the glass by the materials they use, and in fact there is but little actual specific knowledge available.

It is true that in Europe, and in recent years also in this country, there has been considerable progress in the making of certain glasses for special purposes, and we owe much to Guignand, Bontemps, Schott, Hovestadt, Harcourt, and others, who having contributed greatly to our knowledge of the composition and making of optical glasses manufactured in closed pots, or under conditions whereby perfect control could be had of the atmospheric, melting and temperature conditions. But there has been little or nothing done, in a practical way at least, to give us specific information as to the effects of the chemical constituents of glass when the same is made in tank furnaces, in open pots, or under varying fire conditions or how they affect our various processes of manufacture. As I have found by extensive experiments and research, the tensile, crushing and electrical strength, also the fluidity or viscosity of glass can be varied through a wide range by variation of these conditions.

Further, it seems to be pretty well established that in the making of glasses in tank furnaces, the homogeneity of the glass is governed to a considerable extent by the uniformity of fire conditions. However, I make bold to state that the chemical constitution of a glass is the more important factor which makes possible the production of a homogeneous glass in a tank furnace. I mean that the relative proportions of the constituents are more important than the actual constituents; that is to say, a glass may be composed of soda, lime and silica only, and unless the proper chemical proportions are maintained we will not get a uniform and homogeneous product under variable fire conditions, while on the other hand other combinations can be used and if the proportions are right, and the fire conditions are properly maintained for such proportions, homogeneity will result. In this, I believe, we have before us one of the most salient problems that affects the greatest number of glass manufacturers.

It is true that for the production of certain classes of articles, like thermometers, measuring vessels, etc., it is necessary to observe uniform and definite composition, in order that the required expansions, heat re-

sisting properties, electrical properties, etc., may be obtained. But for the glass manufacturers who are producing the greatest tonnage, and the greatest amount of ware in dollars and cents throughout the country to-day, the vital problem consists of:

What can I do to obtain the greatest amount of melted material for the minimum cost? How can I produce it in finished product for the minimum cost? What will assist me in putting my ware into packages, ready for the market, with minimum breakage or loss?

Right here is where the chemical industry can be of incalculable assistance to the glass industry, for if the manufacturers and operators of our chemical works, who mine, manufacture or sell the raw materials to the glass manufacturers will but put their shoulders to the wheel they will assist in turning the glass manufacturer's prejudiced mind from his pagan thought that —"an ounce of practice is worth a ton of theory," and they will, in a short time, sell to the glass manufacturers much of their by-products, waste material, or perhaps raw material, at a larger profit to themselves and at the same time enhance the profit of the glass manufacturer.

I regret that I am not in a position to elucidate more clearly this subject; I can, however, point out a few instances to show the possibilities.

In the average glass factory when trouble occurs and the glass contains various imperfections, or when breakage begins to become excessive, the first thing that will be investigated will be the sand pile. The sand will be immediately condemned should it be a little dark in color or a little too fine or a little too coarse, or not exactly of the same shade of color as the sample (which, in many factories, can be found preserved for the purpose of comparison, and which perhaps was selected at a time when some abnormally good runs were made). The next step will probably be to change the sand and get a carload or so from some other source of supply, when in reality sands do not differ by more than 1 or 2 per cent in the amount of silica which they contain.

Now if instead the manufacturer had gone to his lime bin, and had taken a sample of the lime when his trouble started and had it analyzed it is probable that he would have found that the actual calcium oxide content had increased or diminished by 10 or 15 per cent above or below normal. It is possible that he had been using before a lime which carried 80 to 82 per cent of CaO, but on the next order the manufacturers may have been short of his particular kind and may have shipped him a car from some other source or from another one of their mines where the material had been taken from a greater or lesser depth in a stratum of rock, and which may have contained, say, 50 to 60 per cent of CaO and from 20 to 30 per cent of magnesium oxide. Now his melting conditions had been adjusted originally for lime which contained approximately 80 per cent of CaO with only 2 per cent, or at the most 3 per cent of MgO, so that they were not adjusted to the use of the new lime, with the result that the product was "cordy," "stringy" or hard glass.

In another instance the glass worked may have been using an oxide of manganese for decolorizing purposes which contained, say, approximately 80 per cent of MnO_2, but for some reason he may have purchased manganese from another source and the material may vary 5 to 15 per cent in MnO_2. The result is that the color of his glass goes from white to pink or green, and his glassmaker begins to use various "dopes" for the correction of such troubles, without any knowledge whatsoever of the effect produced by what he uses other than that it is "blue" or smalts, arsenic, antimony, borax, cryolite, fluorspar or nitre. Now if the manufacturers of these products would join with the glass manufacturer in investigating these troubles or would furnish material of known composition, the glassmaker would soon learn to appreciate the value of such knowledge.

There are innumerable instances of this kind. If some of our manufacturers would take steps to furnish to the glass manufacturer raw materials of exact composition which would give him a more uniform product with less melting cost and less loss, or if they would, as outlined above, lend some encouragement to the founding of establishments for investigating problems of glassmaking a great deal could be accomplished.

Lancaster, Ohio.

Inflammability of Mixtures of Gasoline Vapor and Air

The Inflammability of Mixtures of Gasoline Vapor and Air is discussed by G. A. Burrell and H. T. Boyd in Technical Paper 115, of the Bureau of Mines.

The authors in their conclusions say in part: "Two methods for determining the content of gasoline vapor in air are discussed. One has to do with the introduction of the mixture into an exhausted glass vessel, cooling it at the temperature of liquid air, removal of the air, and finally the measurement of the partial pressure of the gasoline vapor by means of a manometer attached to the liquefaction bulb.

"Another method consists in burning the gasoline vapor in oxygen and, from the contraction and carbon dioxide produced, calculating the percentage of gasoline vapor.

"When a 100-c.c. Hempel explosion pipette was used and the mixtures were ignited from the top, there was obtained as the lower limit of complete inflammation a value lying between 1.9 and 2.0 per cent of gasoline vapor. The upper limit under these conditions was found to be between 5.2 and 5.3 per cent of gasoline vapor. The gasoline used had a specific gravity of 73 deg. B. Under the same conditions, except that the mixtures were ignited from the bottom, there was obtained a value lying between 1.5 and 1.6 per cent of gasoline vapor as the low limit. With the same grade of gasoline, with a 2800-c.c. vessel, and with ignition from the bottom by means of an electric flash produced by pulling apart two wires through which a current of 7 amp. at 220 volts was flowing, there was obtained a value lying between 1.4 and 1.5 per cent of gasoline vapor. The high limit under these conditions lay between 6.0 and 6.4 per cent of gasoline vapor.

"When the initial temperature is increased before igniton of the mixtures the low limit is gradually decreased until with an initial temperature of 400 deg. C. the low limit lies between 1.02 and 1.22 per cent of gasoline vapor.

"The range of complete combustion for mixtures of gasoline vapor and air is very narrow, and is between about 1.5 and 2.5 per cent. The amount of carbon dioxide produced reaches a maximum at 2.5 per cent of gasoline vapor. At this point, as the percentage of gasoline vapor increases, carbon monoxide begins to form. At 4.1 per cent of gasoline vapor there is produced 14.0 per cent of carbon monoxide."

The **Bausch & Lomb Optical Co.** received four Grand Prix, one medal of Honor and one Gold Medal at the Panama-Pacific Exposition for the excellence of their products. The four classes in which Grand Prix were received were optical instruments, balopticons, engineering instruments, and range finders. The Medal of Honor was awarded the photomicrographic apparatus and the Gold Medal was awarded the Zeiss lenses.

The Electrolytic Precipitation of Gold, Silver and Copper from Cyanide Solutions*

BY G. H. CLEVENGER

The present unsettled condition of the metal market, more particularly as regards zinc, which is used now almost exclusively as a precipitant in the cyanide process, makes a consideration of electrolytic precipitation, which is apparently the most feasible substitute, of particular interest at this time.

The electrolytic precipitation of gold, silver and copper from cyanide solutions in connection with the cyanide process of gold and silver extraction, has frequently been the subject of satisfactory laboratory experiment, but much less frequently of successful commercial application. This comes about through the fact that experiments carried on for a few hours in the laboratory give no true indication of the life of anodes, formation of by-products, etc., to be expected in continuous operation.

My purpose in presenting the present paper is not to give a theoretical discussion of the subject or to make new proposals for improved types of electrolytic precipitation apparatus, but rather to describe the few commercially successful installations which have been made, calling particular attention to the difficulties which have arisen in their operation, in the hope that it may prove useful to those who have to do with the installation of electrolytic precipitation equipment.

In order that those of our members who are not familiar with the cyanide process may properly appreciate the peculiar and difficult problem which the complete precipitation of gold and silver from dilute cyanide solutions presents, I will digress sufficiently to make this clear before taking up the description of the various attempts to solve the problem. The solutions which are precipitated in present-day cyanide practice may contain a great variety of compounds arising from the decomposition of the cyanide, as well as from its combination with elements occurring in the ore treated, or introduced by chemical methods of precipitation. The principal constituents of such solutions, if zinc precipitation were not used, would be: Simple alkaline cyanides, alkaline hydrate, gold and silver, and copper if it occurs in a soluble form in the ore undergoing treatment. The proportion of these various constituents present, particularly of the gold and silver, is extremely small compared with the amounts of metal present in solutions made by extraction processes in other industries.

In general the simple alkaline cyanide, as indicated by the Liebig titration test, will range in present-day practice from a trace to 0.25 per cent, or a maximum of 1/400 of the solution. In certain cases of sand treatment of silver ores stronger solutions are used, but in general the cyanide strength of the solutions precipitated will fall well below the upper limit given. The alkali generally added is lime, although caustic soda has been used. There is rarely over 100 points present and most generally much less than this, and in some cases practically no protective alkalinity. (One hundred points of alkali correspond to a saturated solution of lime in distilled water at 20 deg. C., i.e., 0.13 per cent.) The proportion of alkali present is therefore in many cases less than the cyanide.

The gold present will range from nothing to 0.5 ounce (15 grams) per ton, and the silver from a trace to 10.0 ounces (292 grams) per ton. In general the proportion of gold and silver in solution is much less than the upper limits given.

*A paper presented at the 28th general meeting of the American Electrochemical Society, in San Francisco, Sept. 16 to 18, 1915.

The grade of the ore treated does not always form a safe criterion of the gold and silver content of the solution, for the reason that the ratio of the weight of solution used to the weight of ore treated, or, as it is generally termed, "the dilution," varies greatly, but in general, as might be expected, is greater with high-grade ores. Thus, if three tons of solution are used in treating one ton of ore, we have a 3 to 1 dilution, and the recoverable value of the ore has been transferred to three parts of solution, the average value of which would be one-third of the recoverable value of the ore treated; or, to take the concrete case of an ore assaying 0.50 oz. (15 g.) of gold per ton (approximately $10 per ton) from which 90 per cent of the gold can be extracted by cyanide solution, there would be dissolved by the solution 0.45 oz. (13.2 g.) ($9) per ton of ore treated. With a 1 to 1 dilution the average content of the solution per ton would be 0.45 oz. (13.2 g.) ($9); with a 3 to 1 dilution the average content of the solution per ton would be 0.15 oz. (4.4 g.) ($3); with a 5 to 1 dilution the average content of the solution per ton would be 0.09 oz. (2.6 g.) ($1.80).

It will, therefore, be apparent that this stage of the cyanide process, the transference of the gold and silver from the solid state as occurring in the ore, to the liquid state as dissolved in the cyanide solution, is unlike most other steps in metallurgy, which are in general to successively concentrate the metal sought into a smaller weight of material. Exceedingly small as is the proportion of gold and silver present in ores which it is possible in present-day practice to profitably treat by cyanidation, the proportion of gold and silver in the solutions requiring precipitation are generally still smaller.

Perhaps a clearer idea of the small amount of metal involved, particularly in the case of gold, will be obtained by expressing the proportion fractionally. In solutions containing 0.50 oz. (14.6 g.) of gold per ton (approximately $10), an unusually high proportion, the gold would form only 14.6/1,000,000 or 1/58,332 part of the solution. In the case of waste solutions, which are or should be precipitated before they are discarded, it is not unusual to deal with solutions containing less than 0.01 oz. (0.29 g.) of gold per ton (20 cents), or only 1/2,916,600 of the total weight of the solution. Tail solutions containing only 1 or 2 cents values per ton are regular practice at many mills using zinc dust precipitation.

At the present market price of silver (about 50 cents per ounce) there would be required about forty times the weight of gold present to give an equivalent value in silver. Therefore, in the treatment of silver ores a much greater weight of metal would be involved, but still the relative proportion of metal to the total weight of solution is small. As gold and silver most frequently occur associated, the absolute weight of metal to be precipitated will depend upon the ratio of these two metals in the ore treated. The greater weight of metal involved in the treatment of silver ores or ores in which silver predominates, perhaps in a certain measure explains the greater ease with which solutions resulting from the treatment of such ores are handled by all precipitation processes.

Copper in solution is an incident of gold and silver extraction, as at present there is no effort made to recover copper in this way; however, this is an interesting possibility, and would be feasible provided the cyanide combined with the copper could be economically regenerated. In many cases the proportion of copper in solution will be less than that of the gold and silver, and, so far, even with electrolytic precipitation, there has been no serious attempt to treat gold and silver

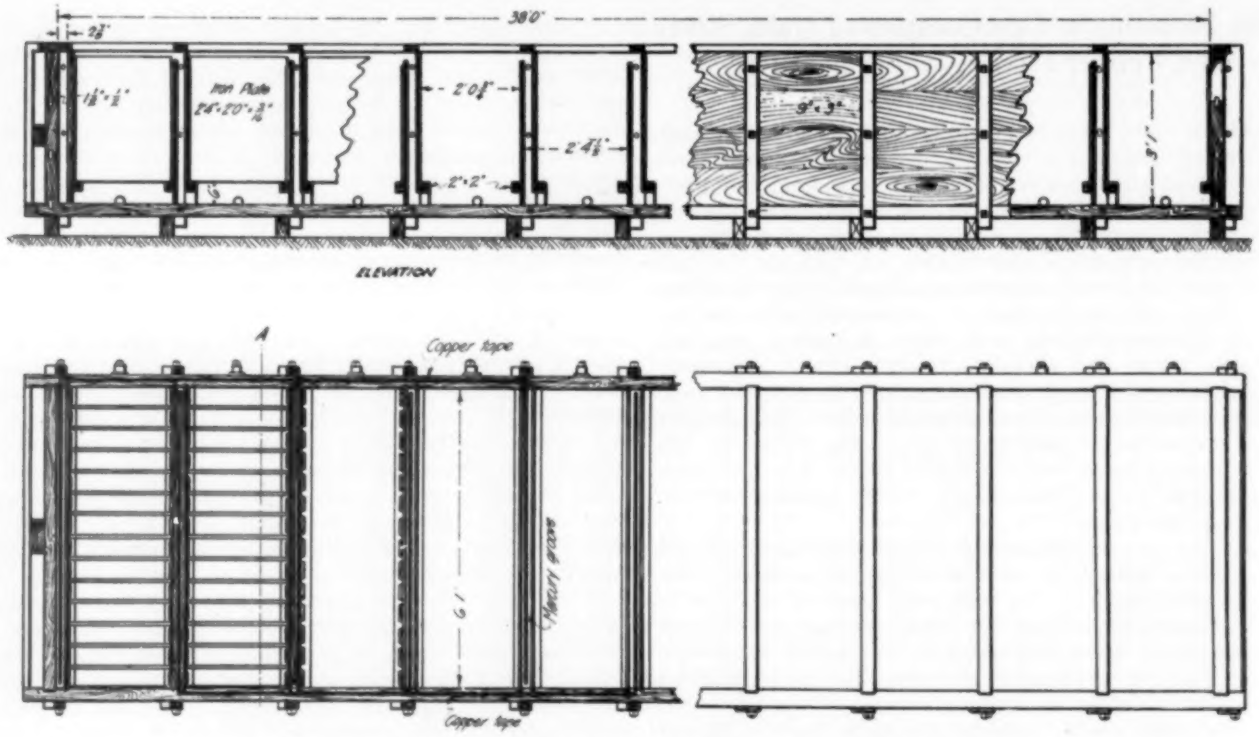

FIG. 1—CONSTRUCTION OF BOXES FOR SIEMENS-HALSKE PROCESS

ores by the cyanide process unless the proportion of readily soluble copper was considerably below 1.0 per cent. The interference of copper with other methods of precipitation, as well as its prejudical effect upon extraction, make a consideration of its behavior with electrolytic precipitation of particular interest, but beyond the province of the present paper.

The electrolytic precipitation of gold and silver from cyanide solutions, therefore, involves the practically total precipitation of an extremely small weight of metal from solutions containing a comparatively small proportion of soluble salts, and which are therefore poor electrical conductors. The fact that the alkaline cyanides are readily decomposed by electrolysis and that the economy of the cyanide process depends upon the continued re-use of the solvent make it imperative to precipitate with the minimum decomposition of cyanide, and preferably with a regeneration of cyanide. The difficulty of the problem at best will therefore be apparent.

Siemens-Halske Process, on the Rand, South Africa

The precipitation of gold and silver from cyanide solutions by electrolysis, employing a soluble anode of the metal to be deposited, had been practiced in electroplating long before the complete precipitation of gold and silver from the dilute solutions resulting from ore treatment was attempted by electrolysis, using an insoluble anode.

In 1887 a British patent was granted on the MacArthur-Forrest process of gold and silver extraction, involving the use of dilute solutions of potassium cyanide and zinc precipitation. In the same year, Dr. Siemens, working independently and acting upon observations made at his plating plant at Berlin, Germany, taken together with the statements of chemical authorities that gold was soluble in solutions of the alkaline cyanides, developed a process of gold and silver extraction involving the use of dilute solutions, more dilute than those at first used with the MacArthur-Forrest process, and electrolytic precipitation.

In the course of this work zinc filings had been tried as a precipitant, but with the very dilute solutions employed electrolytic precipitation proved more satisfactory. The first experimental plant was erected at Siebenburgen for extracting gold from concentrates, and although the process was in successful operation as early as 1888 in other mining localities it was not until a number of years later, in 1893, that the Siemens-Halske process was introduced into the Rand gold field of South Africa.

On the Rand, at first, only the sand portion of the ore pulp resulting from the stamp-crushing and plate-amalgamation process could be successfully treated by cyanidation, as leaching was the only method of treatment then in use. The solutions resulting from sand treatment contained sufficient free cyanide to give satisfactory results by ordinary zinc-shaving precipitation, as then practiced. This method of precipitation was, therefore, almost universally used for these solutions.

With the advent of the decantation method of treatment for the unleachable portion of the pulp, which had previously been allowed to accumulate on account of not being amenable to treatment by leaching, the problem at once arose of precipitating from large volumes of solution which were weak in both cyanide and gold on account of the high dilution necessary in treating slime by the decantation method.

At this time the ordinary zinc-shaving method of precipitation did not give satisfactory results when used with very weak solutions. The Siemens-Halske electrolytic process of precipitation, therefore, came into very general use for precipitating the solutions resulting from slime treatment.

The Siemens-Halske process was first introduced at the Worcester mine. Installations at other mines rapidly followed until at one time there were about twenty in operation on the Rand. In the Siemens-Halske process, iron anodes 1/8 to 1/4 in. (0.3 to 0.6 cm.) thick, and lead-foil cathodes about 0.00032 in. (0.008 cm.) thick were used. In general, the anodes and cathodes were set vertically and about 1½ in. (4 cm.) apart. There was considerable variation in the size

and arrangement of the anodes and cathodes. At the Worcester plant they were 7 ft. long by 3 ft. wide (2.1 x 0.9 m.), but in later installations, to facilitate handling, they were made smaller, as shown in Fig. 1. The anodes were enclosed in sacks of textile material for the twofold purpose of preventing short circuits and of collecting the prussian blue and iron oxide formed from the iron anodes.

The lead-foil cathodes were frequently cut in narrow strips for the purpose of increasing the surface. These were strung upon iron wires mounted in light wooden frames. Another expedient which gave still greater surface was to cut the lead into shavings similar to zinc shavings. These were packed into the space between the covered anodes.

Various arrangements of the precipitation units were tried, but the one which seemed to be the most favored was to construct the containing box as shown in Fig. 1 and Fig. 1a, with alternate wide and narrow compartments, the narrow compartments serving for the downflow of the solution, while the anodes and cathodes were suspended in the wide compartments, through which the solution had an upward flow. This general arrangement will be recognized as being similar to that of the boxes used for zinc-shaving precipitation.

The current density used was from 0.03 to 0.06 amp. per square foot (0.33-0.66 amp, per sq. m.) of anode surface. The aim was to obtain a coherent plating of the gold upon the lead cathodes. After sufficient gold had accumulated upon the cathodes (2 to 12 per cent of their weight) they were removed, melted and the gold recovered by cupellation, either locally or at a central reduction plant.

There was a long and bitter controversy on the Rand regarding the relative merits of zinc and electrolytic precipitation. In 1898, Betty, by means of a drip of strong cyanide solution at the head of the zinc boxes, in conjunction with the zinc-lead couple, which was first proposed by MacArthur in 1894, demonstrated that zinc precipitation could be satisfactorily used for solutions low in both cyanide and gold. After satisfactory precipitation of these dilute solutions by zinc became possible, electrolytic precipitation rapidly lost ground and finally was entirely superseded by zinc precipitation.

Practice at Minas Prietas, Mexico

E. Andreoli, early in 1895, while working with the Siemens-Halske process in South Africa, accidentally discovered the lead peroxide anode, and although the advantages of peroxidized lead over iron as an anode material were at once recognized, it does not appear to have been used to any exent in that locality, possibly for the reason that electrolytic precipitation, at the time that this development was announced, was being rapidly displaced by zinc precipitation. After investigating many possible cathode materials, Andreoli sugested iron as being the best on account of its cheapness, strength, and the firm adherence of the gold to it. Borchers, however, states that from the electrochemical standpoint the use of iron cathodes is theoretically incorrect. Andreoli proposed recovering the gold from the iron cathodes by dipping them in a bath of molten lead. The gold was to be recovered from the lead by cupellation. The iron cathode used in this way does not appear to present any advantage over the lead-foil cathode, as it also involved the use of lead and necessitated the operation of cupellation.

In 1899, Charles Butters, who had been prominently identified with the introduction of the Siemens-Halske process in South Africa, assisted by two members of his former staff, H. T. Durant and E. M. Hamilton, developed a new electrolytic precipitation process which

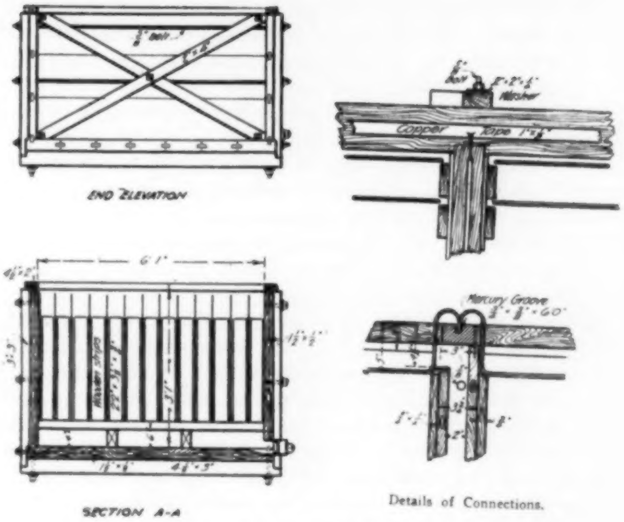

FIG. 1A—DETAILS OF SIEMENS-HALSKE BOXES

was first sucessfully used for a number of years in connection with the cyanidation of a large deposit of pan-amalgamation tailings, and later of ore directly, from the mine at Minas Prietas, Mexico.

The original installation for electrolytic precipitation consisted of six wooden boxes, as shown in Fig. 2, 30 ft. (9 m.) long by 10 ft. (3 m.) wide and 5 ft. (1.5 m.) deep, having a slope of 1 in. to the foot (8 cm. to 1 m.) toward one side, to facilitate the removal of precipitate. The boxes were divided by wooden partitions into alternate wide and narrow compartments, twelve of each. The partitions were so arranged as regards the bottom that the narrow compartments throughout the box served only for the downflow of the solution, whilst the wide compartments, in which were suspended the anodes and cathodes, served for the upward flow of solution.

This general arrangement of the compartments is the same as that used with the Siemens-Halske process. Each wide compartment was fitted with eighteen lead anodes whose surface was coated with lead peroxide, formed by electrolysis in a special cell, and seventeen cathodes composed of lead foil, cut in strips, strung upon wires supported by wooden frames similar to the cathodes used with the Siemens-Halske process in South Africa.

The current was supplied by two Siemens-Halske dynamos, each capable of developing 250 amp. at 30 volts, feeding into copper bus bars $1\frac{1}{4}$ x $\frac{1}{4}$ in. (3.1 x 0.6 cm.) laid on top of the boxes.

In order to insure good contacts, the wires leading from the individual anodes and cathodes were soldered to the bus bars, mercury-cup contacts having proved unsatisfactory.

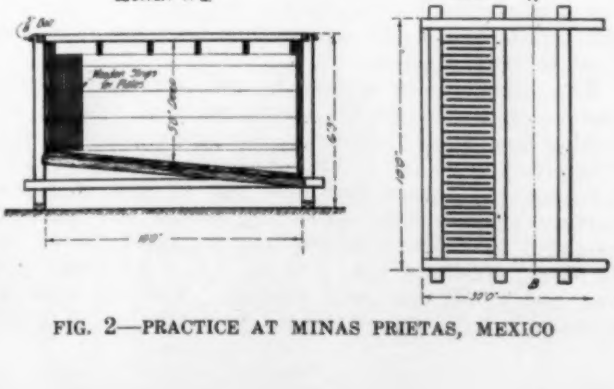

FIG. 2—PRACTICE AT MINAS PRIETAS, MEXICO

The solution passed through three sets of boxes, each set comprising two boxes set in tandem. One set of two boxes was used for precipitating the solution resulting from sand treatment and two sets of four boxes for precipitating the solution resulting from slime treatment.

The current density was so regulated that the metals were deposited as a flocculent precipitate which largely fell to the bottom of the compartments in the form of a fine slime, as in zinc-shaving precipitation, rather than as an adherent coating upon the cathodes as in the Siemens-Halske process.

After a short period of operation, it was found that the precipitate did not all fall to the bottom of the box, but that part of it formed as a rather loosely-adherent mass on the cathodes. This necessitated washing and shaking of the cathodes when it was desired to make a complete clean-up. It was soon apparent that the fragile lead-foil cathodes could not long withstand such treatment, so an investigation was started with the view of finding a more satisfactory cathode. This resulted in abandoning the lead-foil cathode in favor of a cathode made from ordinary tin-plate, which possessed the necessary strength and from which the precipitate could be readily brushed without removal of the cathodes from the containing box.

The pan-amalgamation tailing cyanided at this plant resulted from the treatment by raw pan-amalgamation of a comparatively simple siliceous silver-gold ore. The tailing contained copper, mercury and chlorides as a result of the chemicals added during amalgamation. After the tailing deposit had been exhausted, the low-grade ore which had been left in the mine was treated. The pulp was separated into sand and slime, the sand being treated by percolation and the slime by agitation, natural settlement and decantation. The volume of the solution precipitated varied as did also its metal content. The percentage of cyanide and alkali were less variable, but by no means constant.

Below are given average figures covering two months' operation, for solutions resulting from sand treatment when pan-amalgamation tailing was being treated. Average amount of solution precipitated per 24 hr., 216 tons. Current density 0.55 amp. per square foot (60 per sq. m.) of anode surface. The voltage across the anodes and cathodes varied in the different compartments, but averaged about 3. The head solution, or solution entering the precipitation boxes, contained: 0.147 oz. (4.14 g.) gold per ton; 3.51 oz. (102.4 g.) silver per ton, and 0.0792 per cent of cyanide in terms of potassium cyanide. The tail solution or solution leaving the electrolytic precipitation boxes contained 0.013 oz. (0.379 g.) gold per ton; 0.29 oz. (8.46 g.) silver per ton, and 0.0938 per cent cyanide. The gain in cyanide was 0.0146 per cent. As there was used 1.2 tons of solution in treating each ton of sand, the cyanide apparently regenerated amounted to 0.35 lb. (0.16 kg.) per ton of sand. The percentage of gold precipitated was 91.0 and the percentage of silver precipitated was 91.7. No attempt was made to lower the gold and silver in the tail solution, as none of it was used for final washes.

The following are average figures covering the same two-month period for the precipitation of solution resulting from slime treatment: Average amount of solution precipitated per 24 hr., 480 tons. Current density 0.3 amp. per square foot (3.3 per sq. m.) of anode surface. The voltage across the anodes and cathodes averaged 2.6. The head solution contained: 0.133 oz. (3.88 g.) gold per ton; 1.45 oz. (42.3 g.) silver per ton, and 0.0409 per cent cyanide. The tail solution contained: 0.055 oz. (0.160 g.) gold per ton; 0.15 oz. (4.37 g.) silver per ton, and 0.0527 per cent cyanide. The gain in cyanide was 0.0118 per cent. As there was used four tons of solution in treating each ton of slime, the cyanide apparently regenerated amounted to 0.94 lb. (0.43 kg.) per ton of slime. The percentage of gold precipitated was 88 and the percentage of silver 89.6. When the solution flow was cut down to two-thirds normal, the tails contained 0.0025 oz. (0.073 g.) gold and 0.06 oz. (1.75 g.) silver per ton. The regeneration of cyanide was doubtless greater with the solution resulting from the treatment of the slime on account of the greater percentage of copper which it contained. When treating ore directly from the mine, which contained little or no copper, the regeneration was not sufficient to be detected by ordinary titrations.

(To be concluded)

Paint*

BY G. B. HECKEL

Paint is a product of science and civilization, and a result of progress and evolution.

History of the use of paint by all races is practically the same. The first pigments used are the natural earth colors or simple vegetable dyes. They are devoted to personal decoration—commonly heraldic—and later their use is extended to other decorative purposes. It is only in a higher stage of development and civilization that the protective value of paint is recognized. This evolution is the natural accompaniment of change from the nomadic state, where dwellings are temporary, to the fixed life of civilized society.

Let us consider a typical high-grade paint formula. It contains the following ingredients:

ANALYSIS OF PEA GREEN
(United States Standard Measure)

	Per cent
Pigment by weight	48.00
Thinner by weight	52.00
	100.00
Thinner is composed of:	
Linseed oil	85.00
Asphaltum spirits	3.00
Turpentine	1.00
China wood oil	2.00
Japan dryer	9.00
	100.00
Composition of pigment:	
Basic carbonate white lead	15.00
Basic sulphate white lead	20.00
Zinc oxide	44.00
Magnesium silicate (asbestine)	3.00
Calcium carbonate	2.00
Barium sulphate (blanc fixe)	10.00
Aluminium silicate	3.00
Lead chromate	2.30
Ferric-ferro cyanide	.70
	100.00
Coloring is composed of:	
Pure chrome green	100.00
Composition of Japan dryer:	
Kauri gum	1.67
Oxide lead	8.45
Manganese peroxide (black oxide of manganese)	2.00
Linseed oil	26.44
Turpentine	61.44
	100.00

Besides these ingredients that are mentioned on the label, we may also notice that the container is made of tin plate; that the can is soldered; that the labels are printed with two colors of printing ink on white paper, and pasted on the can. Finally we may recall that such cans are packed with sawdust in wooden boxes nailed together with steel wire nails. Keeping in view the finished can and its contents, I think you will catch my drift when I say that all science and all civilization have contributed to the making of the can of paint bearing this label and that without science and civilization it would be unthinkable.

*An address made before the First National Exposition of Chemical Industries.

Components of Thinner

Let us consider briefly the ingredients, one by one: The first is **linseed oil**, a product of the flax plant *Linum usitatissimum*. The flax plant was not first cultivated by man for the seed or its oil. Its earliest use was for the making of linen cloth. The great masters of early European art knew nothing of linseed oil, and the first use of the seed was medicinal. To-day in the United States alone over 25,000,000 bushels of flaxseed are consumed annually in the manufacture of linseed oil, the great bulk of which goes to the production of paint and varnish. To produce so much seed requires from 2,000,000 to 2,500,000 acres of soil. Its cultivation requires many farmers and laborers, much special machinery; its storage and transportation utilizes elevators, railroads, steamships; its use for oil-making requires elaborate plants, much special machinery, and the treatment of the oil for its various uses involves chemistry and the mechanical arts. Moreover, the oil-growing flax is itself a product of agricultural science, a science which is to-day more ardently pursued by plant specialists than ever before. The proper preparation and use of linseed oil involves the results of profound study and investigation, which to-day are still far from completion.

In the manufacture of linseed oil the flaxseed, cleaned from foreign seed and other impurities, is first ground in a series of roller mills. The resultant meal is treated in a special heater with live steam to break up the oil cells. This hot meal is then pressed into the desired form and size for the oil presses, in a cake former, and a number of those cakes are stacked, one above the other, in camel's-hair or other fabric cloths, between the plates of a specially devised hydraulic press. An enormous pressure is applied and the expressed oil is filtered and collected in settling tanks where the moisture, plant mucilage, etc., settle to the bottom, while the clear oil collects on top and is drawn off and sold as raw linseed oil.

Linseed oil is a very complex organic chemical compound, but consists essentially of the glycerides of a number of fatty acids. Of these the most important in connection with our subject are the glycerides of linolic and linoleic acids, to which the oil owes its characteristic property of absorbing oxygen and thereby becoming converted to linoxin—the characteristic rubber-like product of "dried" linseed oil.

The presence of certain metals facilitates this process, and these metals are incorporated with the oil by heating their compounds with the raw oil. Recent investigations indicate that the three metals practically most effective for this purpose are lead, manganese and cobalt, and consequently advanced manufacturers have generally abandoned the use of other compounds.

It will be noted that the liquid portion of our paint contains 85 per cent of linseed oil. The fact is significant, for while linseed oil leaves something to be desired when we contemplate the ideal paint, it is nevertheless the most satisfactory paint oil for general use known to us up to the present time.

The remaining fixed oil in our formula is **China wood oil**, of which only 2 per cent is present. China wood oil is comparatively a recent addition to the raw materials of paint and varnish manufacture. It is pressed from a nut grown on a tree (*Aleurites cordata*) indigenous to the Yangtze Valley in China. The variety producing the oil nut is known to the Chinese as ying tzu tung (apple fruit Tung), and the tree is cultivated by the Chinese farmer for its oil. It grows to a height of about 25 ft., bears large green leaves, small pinkish flowers and large green fruit somewhat resembling an apple. The seeds are large and poisonous, and from them the oil is obtained. The machinery used is primitive, consisting essentially of a wooden press operated by wedges. The oil is traded, along with other agricultural products, to merchants at Hankow, Fatcheu and Canton. It has been used in China for ages, much for the same purposes as linseed oil is used in this country, and it is said that the extracted seed residues are the raw material for the manufacture of India ink.

But little is as yet known generally regarding the chemistry of this oil. It has drying properties similar to a certain extent to those of linseed oil, and the rate of hardening is accelerated by the same agencies that promote the oxidation of the more familiar oil. The chemical process appears, however, to differ, since while linseed oil hardens progressively from the surface inward, China wood oil seems to harden or set simultaneously throughout. This peculiarity led to rather expensive disasters in the earlier attempts to utilize the oil in this country. The drying salts are incorporated in practice at a comparatively low temperature, but in these earlier experiments the oil was treated at the temperature common in the treatment of linseed oil, with the result that the entire batch suddenly thickened to a consistency of rubber in the kettle.

While the use of this oil is still the subject of experiment, it has established itself an important place in the varnish industry, and is making rapid strides in the paint industry, especially in the manufacture of flat interior wall paints.

The two volatile ingredients of our formula are asphaltum spirits and turpentine. **Asphaltum spirits** is one of the lighter products of petroleums having an asphaltum base. It corresponds to the benzine which is produced from petroleums with a paraffin base.

The chemistry of these hydrocarbons, while interesting, plays no part in the chemical structure of the paint film, since their office is purely mechanical and they disappear completely in the drying of the paint. As is well known, the petroleums found in some localities yield, on distillation at high temperatures, residues containing paraffin, while similar oils from other localities yield asphaltums as residues. The best known petroleums of the latter class are those produced in Texas, California and the Island of Borneo. Petroleums are distilled by fractionating, the products passing over at the lower temperatures being classified progressively as petroleum ethers, naphthas and gasolines and benzines. At still higher temperatures the illuminating oils pass over, followed by the lubricating oils. Asphaltum spirit is the benzine of the asphaltum petroleums. It boils at a higher temperature than the corresponding paraffin product, has a higher specific gravity and is, on many accounts, far preferable as a volatile ingredient of paints. I personally believe that the formula before us is mechanically improved by the presence of this material and I am convinced that it is in no way injured by it.

Turpentine is the essential oil of certain pines, principally *Pinus Australis*, growing over large areas of our Southern States. It is distilled in a current of live steam from the sap of this tree, the residue being rosin. The industry, owing to the character of the labor available in the pine districts, is crude and wasteful both to the timber involved and to the product, though more conservative methods are coming into use through the effort of the United States Department of Agriculture.

The negro workman in a turpentine orchard cuts a so-called "box" on one side of the tree, in which the sap collects, and from which it is from time to time dipped and carried to the still. As the flow of sap decreases, the bark is removed and the wood scarified higher and higher above the "box." In the larger trees

several boxes are cut at different points on the circumference, weakening and in time killing the tree. The crude sap or gum is charged into a still with water, and on heating, the volatile turpentine passes with the steam to a worm condenser. The turpentine is decanted from the condensed steam on which it floats.

Turpentine in paint probably acts in two ways: First, as a volatile thinner, of which the effect is purely mechanical; and secondly, as a conveyor of oxygen, perhaps catalytically. At any rate it was the conclusion of a French technical commission who investigated the subject, that turpentine hastens the drying of paint to an extent not accounted for by its volatility.

The principal turpentine forests of to-day are located in Florida, southern Georgia and Louisiana, the immense forests that formerly covered vast areas in North and South Carolina and northern Georgia having been largely destroyed by the wasteful methods in vogue. Another form of turpentine has appeared in the market during comparatively recent years. It is familiarly known as wood turpentine, being produced, by various methods of distillation, from pine wood wastes. When properly prepared and purified, there appears to be no practical difference in its properties as a paint vehicle from those of sap turpentine.

The remaining liquid ingredient of our formula is **Japan dryer.** This consists essentially of the linoleates of lead and manganese, with a small percentage of Kauri gum. It is prepared by boiling linseed oil with the proper percentages of compounds of manganese and of lead, adding thereto a certain quantity of melted Kauri gum, and reducing the product while warm, with turpentine, benzine or a mixture of the two. The lead compound used in this dryer is red lead and the manganese compound is the black oxide, while the reducing agent is turpentine and Texas benzine—asphaltum spirit.

The manufacture of red lead leads us at once into the mining regions of the West, where in some districts lead is produced from practically pure ores, while in others it must be separated from its commingled silver, zinc, etc.

For the manufacture of the so-called Dutch process white lead it is necessary to have the metal free from silver, manganese and iron; but for the manufacture of the ordinary oxides purity is not so important. The metallic lead comes from the smelter in the form of pigs, which are melted in a low, flat oven in which the lead spreads out in a thin layer and is mechanically worked so as to expose continually fresh surfaces to the action of the air. The product is the monoxide of lead —massicot. This oxide is ground with water to remove metallic particles, which are returned to the furnace, while the oxide is collected in settling tanks. If the temperature in the furnace rises too high it becomes litharge—crystalline lead monoxide—which cannot be further oxidized.

The amorphous monoxide, being further treated in the same or a similar oven, at a low red heat, with free access of air and constant stirring, gradually takes up more oxygen and is converted into red lead—a combination of the monoxide and the dioxide, in the proportion of about two parts of the former to one of the latter. The product is usually stated as having the formula Pb_3O_4, but commercial red lead is, as noted, a mixture of oxides rather than a definite chemical compound.

The black oxide of manganese, known to mineralogists as pyrolusite, is a natural product, of which the principal sources of supply are in the Caucasus Mountains, in the Hartz Mountains and elsewhere. Chemically, it is the dioxide of the metal manganese. The miners are the wild mountaineers of eastern Europe, and the mineral before it reaches America, passes through southern Russia, the Black Sea, the Dardanelles, the Mediterranean and so across the Atlantic. For the use of the varnish and dryer manufacturer it is subjected to mechanical purification.

These two metallic oxides readily replace the glycerin in linseed oil at moderate temperatures, forming oleates and linoleates, while the glycerin is decomposed and driven off.

The addition of a resin—in this case Kauri gum—at a moderately high temperature also probably induces the formation of resin acid compounds of the metals.

The driers made with lead and with manganese have sharply distinguished properties, of which advantage is taken by the well-informed manufacturer, who knows that certain proportions of the two yield better average results than either alone. He also carefully calculates the percentage of the metal in the drier to the oil to be oxidized. Kauri gum, besides helping the quality of the japan, has also been shown by experience to serve a useful purpose in paints containing high percentages of zinc oxide. It is found only in New Zealand, where ancient forests of the tree which produced it—the *Dammara austaralis* and other varieties of Dammara—have been buried for ages in the earth. It is mined systematically by trenching and is cleaned, sorted and classified by hand.

Components of Pigment

We have now briefly covered the liquid portion of our formula and in the course of our survey have gone to North Dakota for flaxseed, to Florida for turpentine, to Texas for benzine, to China for wood oil, to Colorado and Montana for lead, to the Caucasus for manganese, and to New Zealand for Kauri gum. Even at this point we may begin to see that for this ordinary can of mixed paint the manufacturer has been under the necessity of calling upon many industries, several races and different quarters of the globe. It is no less so with the remaining items of our formula and the package in which it is sold. **Lead hydrocarbonate** is the first named of the solid ingredients. In this case it happens to be Dutch-process white lead.

Lead hydrocarbonate or basic lead carbonate is a molecular combination of the hydroxide and the carbonate of lead in about the proportion of two parts of the latter to one of the former, though these proportions are only approximated in actual practice. The accepted formula, however, is $2PbCO_3, PbH_2O_2$. Of the three processes used to any extent for the manufacture of this product, two employ acetic acid in an intermediary step of the chain of reactions, while the third dispenses with it.

The *old Dutch process,* so called—though it has undergone great improvement in English and American practice—starts with desilvered lead pigs, known in the trade as "soft lead." These are melted, and the molten lead is distributed in shallow molds on an endless-chain belt. The molds give the metal the form of a flat circular grating or buckle about 3/16 in. thick by 5 in. in diameter. These buckles are packed into earthenware pots, having at their bottom shallow wells containing each about half a pint of vinegar or dilute acetic acid.

The charged pots are arranged in tiers between layers of spent tan bark, where they are allowed to remain undisturbed for about 130 days. By the fermentation of the tan bark heat is generated and carbonic acid liberated. The heat vaporizes the acetic acid, which attacks the lead, coating the buckles with basic lead acetate. This in turn is attacked by the carbonic acid, producing the basic carbonate and liberating neu-

tral lead acetate, which attacks the metallic lead beneath, producing again the basic acetate.

The process thus continues progressively until most of the buckle has been altered to the basic carbonate. The buckles being removed from the pots are subjected to mechanical treatment which separates the corroded from the uncorroded portions. The white lead after being ground, washed, floated and dried, enters commerce as dry white lead. The special characteristics of corroded white lead are its excellent working properties and low oil consumption, giving a high degree of opacity or color-body in the finished paint.

The second process, commonly known as the "*quick process*," also starts with desilverized pig lead. This is melted and finely comminuted in a steam blast, and the granulated product is charged into large, slowly revolving wooden drums, where, after being moistened with dilute acetic acid it is subjected for some hours to the action of purified carbonic acid gas from burning coke. The slow revolution of the drums insures the exposure of the entire mass to the action of the gas.

The chain of chemical processes involved is probably identical with those described for the old Dutch process. The mechanical treatment of the crude corroded product is essentially the same. The finished product is more uniform in the size of particle than Dutch-process lead and finer in texture. This involves a larger oil consumption and a consequent decrease in opacity or color body of the completed paint.

The third process, known as the *mild process*, because of the fact that acetic acid is not used, is applicable to pig lead of any description. In this process, also, the metallic lead is finely comminuted in a steam blast. In both this and the preceding process there is a preliminary surface hydration produced by the action of the water vapor on the lead particles. The finer particles are charged into revolving drums containing water and there subjected to the action of air under low pressure for several hours. The lead is thereby converted into the basic hydroxide. This hydroxide is then subjected in similar drums to the action of purified carbonic acid gas for the requisite time, until the conversion to the basic carbonate has been carried to the proper point. The product is extremely white, uniform and pure, requiring only water-floating and drying to fit it for use.

The second pigment of our formula is **basic lead sulphate** or basic sulphate white lead. This is a sublimation product, and is produced directly from the native ores of Missouri—lead sulphide—by oxidation at a high temperature in a current of air. The comminuted ore is charged in a special furnace with coal or other fuel and is subjected to a hot-air blast. The sulphide takes up oxygen, volatilizes and is carried through a series of cooling flues to fabric bags, in which it is collected.

This is the process in outline, though not in detail. The reaction involved is simple; the lead sulphide, PbS, takes up four equivalents of oxygen from the air being converted into lead sulphate, $PbSO_4$. At the same time it is also claimed, with much probability, that there is formed a certain proportion of the basic lead sulphate, $Pb_2S_2O_9$. At any rate analysis always yields an excess of oxygen, which is usually calculated to lead oxide, the percentage of which ranges from fourteen to twenty. The product, furthermore, always contains a small percentage (five to six) of zinc oxide, which comes from the zinc sulphide associated with the ores used.

It may be said in passing that lead sulphate produced in the laboratory is a very unsatisfactory pigment, exhibiting none of the characteristics of the "sublimed" white lead. The latter, on the other hand, is extremely useful, and in certain combinations has come to be regarded as almost indispensable. The particles of this pigment are extremely fine and uniform, approaching the particles of zinc oxide in this respect. As a pigment, it stands between corroded white lead and zinc oxide in most of its characteristics. Paints made with it chalk more freely than paints made with the former, but on the other hand, they retain their color better, and do not "check" so freely. Proper combination with zinc oxide restrains the characteristic chalking while the hardening peculiar to zinc is in turn restrained.

Our third pigment is **zinc oxide.** Zinc is peculiar in that it is the only metal in common use produced by distillation. It is volatile at an easily attainable temperature and advantage is taken of this fact in recovering the metal from its ores. The hot metallic vapor is also readily oxidizable, and if exposed to the air, will take fire, burning with a green flame to zinc oxide.

The oxide is produced by two different processes. One, known as the French process, taking advantage of the fact just mentioned, volatilizes the metal in a current of air and collects the resultant oxide in closed chambers.

In the other process, known as the American process, the oxide is produced directly from the ores. On the nature of the ore used depend the individual characteristics of the resultant oxide.

In this process the comminuted ores are mixed with powdered anthracite and charged into closed furnaces having perforated grate bars. Combustion is started in the anthracite and a blast of air is forced through the perforations in the grate. The heat smelts the ore and volatilizes the zinc, and the metallic vapors promptly combine with the oxygen of the blast, producing zinc oxide. This oxide is carried through a series of cooling flues and collected in fabric bags.

The particular oxide used in this formula is made from New Jersey ore, and on that account is of some interest. This ore is unique in that it occurs in commercially available quantities, nowhere else in the world. It is known as franklinite, and consists of the oxides of zinc, manganese, and iron in molecular proportions—crystallizing as a true mineral. It is closely associated in the vein with other compounds of zinc—the anhydrous silicate, the oxide, etc. A peculiarity of the product is that the oxide recovered is practically free from impurities, averaging over 99 per cent pure oxide. The oxides produced from the ores mined in other localities usually contain from 5 to 15 per cent of lead sulphate, due to the presence of lead sulphide in the vein.

The characteristics of zinc oxide are too well known to require extended comment. It is the finest and whitest of all white pigments; is chemically quite stable, the only chemical changes possible in practice being to the sulphide or to the carbonate, while is also white. It is bulky and hence carries a high percentage of ōil in the finished paint; and finally, when properly used, it is very durable. One is fairly safe in saying that if oxide of zinc had not been introduced as a pigment, there would have been no prepared paint. It was produced as a commercially available pigment, in answer to a demand that had been voiced in Europe from the closing years of the eighteenth century, to the time of its introduction about the middle of the nineteenth. This demand for a non-poisonous white pigment finally received a satisfactory response from a contracting painter of Paris, Le Claire, who was also celebrated as a philanthropist and is known to this day as "the father of profit sharing." Practically every great chemist of Europe from Lavoisier to Faraday had his try at the problem.

Our next pigment is **magnesium silicate** in the form

of asbestine. This product comes principally from Canada. Its usefulness in the paint formula depends entirely upon its physical form, which is acicular or rod-like. Its office in the paint film has been compared to that of the hair in plaster or the rods in reinforced concrete. It is without special value either for opacity or protection, but aids in holding the materials in suspension and very probably also in resisting stresses in the dried paint film.

Our fifth solid ingredient is **calcium carbonate**—in this case a natural product from Missouri—a dolomitic crystalline rock, finely ground for the purpose. Calcium carbonate, as used in paint manufacture, comes to us in two forms. Whiting, Paris white, etc., are the pulverized and floated chalk supplied principally by the chalk cliffs around Dover, England; the calcareous skeletons of innumerable diatoms that once populated the waters of an ocean covering that portion of the earth, ages before the advent of man; while the product used in this formula is from a similar geological source, but in succeeding epochs subjected to heat and pressure, which gave it a crystalline structure. As a rule manufacturers in selecting from these two forms are governed by the conditions; if the remaining inert pigments are crystalline, Paris white is selected; if not, then the so-called mineral primer is preferred.

Either will neutralize any free acid in the paint, but the mineral primer will in addition give the "tooth" which is thought desirable in the manual work of painting. The only other crystalline pigment in our formula is the asbestine, so mineral primer rather than a form of chalk has been selected for this formula.

Barium sulphate is the next on our list, and is used in the form of the chemical precipitate—blanc fixe. The sulphate of barium in the form of barytes is a natural, crystalline product, which retains its crystalline form, no matter how finely comminuted.

It is found associated with lead, zinc and other ores in most mineral regions. That used in the United States, however, comes principally from Missouri and the Alleghenies in Central Virginia, Tennessee, etc.,—Missouri furnishing the larger proportion. There its production is in the hands of farmers who collect and cart it to the railroads in the fall and winter, to be manufactured into pigment at St. Louis and neighboring points. In the Allegheny regions the mineral is procured by mining.

Blanc fixe is produced by transforming the natural product into a soluble compound and precipitating it from dilute solution with sulphuric acid or a soluble sulphate. The product is chemically identical with barytes, but physically quite different, being very finely divided and amorphous.

Silicate of alumina is the next ingredient of our white base. Technically it is a washed and floated China clay, naturally produced by the disintegration of certain feldspars, the soluble potassium and sodium salts having been washed away. The percentage here used is small, but it has a physical influence on the suspension of the other pigments, in the brushing qualities of the paint and on the quality of the paint film.

The remaining ingredients of our formula are the colors required to produce the desired tint. They have no influence on the quality of the paint. The yellow in this combination is **lead chromate**—chrome yellow. It is produced by the reaction of a soluble chromium salt, usually sodium bichromate, on a soluble lead salt, usually lead nitrate, both in solution. The neutral chromate of lead $PbCrO_4$, being insoluble, is precipitated. The production of this familiar pigment again takes us far afield. The chromium used in making the chromates is obtained from an ore of iron known as chromite. It is a chromate of iron, having the composition $FeCr_2O_4$. It is found in small quantities in Pennsylvania, Maryland, California and elsewhere in the United States, but the main sources of supply are Asia Minor and Australia. Large quantities of these ores are imported into England, Germany and the United States for the sole purpose of manufacturing the chromium salts of potassium and sodium. The process is intricate and difficult, so that the manufacturers are few in number. There is also some demand for the mineral in the manufacture of special steels.

The remaining pigment is **Prussian blue**—the potassio-ferro-ferri-cyanide of iron. This material brings us once more into the field of organic chemistry, the non-metallic component of the blue being cyanogen, which is most familiarly known as a component of hydrocyanic or prussic acid and the cyanides of potassium, etc. The chemical composition of the color is indicated by the formula $K_2Fe_2 2FeC_6N_6$.

The cyanides are obtained from organic wastes containing carbon and nitrogen, principally the residues from gas works.

In practice, in the manufacture of chrome green as used for tinting in the present instance, the colors are precipitated simultaneously from solution, either with or on the base, which in this case is the blanc fixe shown in the formula.

The Paint Factory

We have now glanced hastily at the characteristics of our several ingredients, but they are still only raw materials and require a long series of mechanical operations before our can of paint will be ready for use, not to mention the detailed work of the chemist to determine the quality of the materials themselves.

A modern paint factory is a complicated institution, and in the limits of such a paper as this can only be touched upon briefly and hastily. Power in the most modern plants is generated at a central point and is distributed to the units in the form of electrical energy. As a rule the raw materials are elevated to the highest point in the plant, so that the product, in its several steps toward completion, may fall by gravity from each point to the next in the process.

The dry pigments are ground separately to the form of a paste with linseed oil. The various components of the white base are then thoroughly incorporated with more oil, the whole is then mixed with the rest of the oil and the remaining thinners in a mechanical agitator, the tinting colors being added either here or at the preceding step, and the exact tint is attained by addition on the judgment of the expert tinter. The finished paint is measured mechanically into tin cans, which are also soldered and labeled by machinery, and finally these cans are packed in cases holding a given number and guarded from injury by sawdust placed between them. The boxes are then nailed, shut, marked and shipped to the distributors. This is the mechanical routine in the barest outline; but we may observe that it involves the use of building materials, fuel, copper wire, tinplate, paper, printing ink, paste, box lumber, sawdust, wire nails, etc.

The manufacture of tinplate is an important industry in itself, involving a branch of the steel industry in the production of the plates for this use. These plates are cleaned by chemical means, heated, and coated with metallic tin by dipping in a bath of the molten metal. To obtain the tin for this use we must again go to distant regions. The ores are found in small quantities in various parts of the United States.

Cornwall, from the time when the Phoenicians traded to Britain for tin to the days of the first McKinley tariff,

was the chief source of the world's tin supply. But the drain finally told on the natural resources, and the bulk of the tin consumed to-day comes from the Straits of Malacca and from Australasia. In the former locality it is recovered by placer mining methods and in the latter by the usual methods of underground mining. The ore is found in two forms, as the oxide, casserite, and as the sulphide, stannite, in which latter form it is associated with iron. The smelting of the ore for the metal is done principally in England and other parts of Europe.

The paper for our label is a product of sulphite wood pulp, as is most of the paper used for advertising paint. We need not enter further into this subject except to note that our industry involves also the paper manufacturing industry.

Similarly we may note in passing that the printing ink manufacturer and through him the lampblack manufacturer, the color maker and the varnish manufacturer are involved.

Finally, in the consumption of paste, we return once more to the farmer, on whom we called in the first instance for our linseed oil.

The manufacture of this important product, paint, formerly based on empirical experience, is more and more coming under the jurisdiction of the trained technical man. To him we owe the fact that we have now at our command special paints for many special purposes: Flat wall paint for interior decoration; paint for the protection and decoration of concrete; rust-inhibitive paint for the preservation of steel structures, etc.

We know a great deal about paint, in a general way. There is a mass of experimental data on hand to be correlated, interpreted and made the basis of broad general laws. To this phase of the subject the trained paint technologists are now turning their attention.

In conclusion, permit me to say that there is no subject more interesting or more important to us as citizens or as property owners. As citizens we owe largely to paint the beauty and wholesomeness of our surroundings and as property owners, the preservation of our structures.

Educational Bureau, Paint Mfrs. Assn. of U. S.

Synopsis of Recent Chemical and Metallurgical Literature

Gold and Silver

The Tonopah Plant of the Belmont Milling Co.—Cyanide practice at Tonopah was described in a paper by A. H. JONES, superintendent of mills for the Tonopah-Belmont Development Company, at the A. I. M. E. meeting in San Francisco. The cost of the plant, designed to handle 500 tons of ore per day, is shown in Table I.

A flow-sheet is shown in Fig. 1, giving details of machinery used.

The ore is crushed to 1-in. size and automatically sampled and weighed.

The consumption of wearing parts in the crushing plant amounts to 0.0325 lb. per ton of ore at an expense of $0.00555.

Sixty 1250-lb. stamps crush through 4 and 6-mesh Taylor ton-cap screens at the rate of 8.88 tons per stamp per 24 hours. Five tons solution is used per ton of ore stamped. The solution has a cyanide strength of 5 lb. and a lime strength of 1 lb. Metal consumption in stamping is as follows: Forged steel dies, 0.207 lb. per ton of ore; chrome steel shoes, 0.179; discarded iron in dies and shoes equals 0.064 lb. and 0.108 lb. per ton of ore respectively, making a total of 0.553 lb. per ton

TABLE I.—CONSTRUCTION COSTS, BELMONT MILL

	Excavation Concrete Walls and Foundations	Floors and Machinery Foundations	Buildings		Machinery, Including Erection, Piping, Wiring, Belting, Etc.	Totals
			Frames	Covering		
Crusher plant	$5,760.72	$2,527.58	$2,230.72	$1,476.60	$21,174.96	$33,170.67
Inclined conveyor	166.41	238.02	1,771.75	585.19	3,620.79	6,382.16
Battery bins	399.00	489.70		2,067.69	3,475.14	6,431.53
Stamps		8,797.82			36,873.06	45,670.88
Tube mills and classifiers		3,180.95			40,127.89	43,308.84
Callow cones		26.02			856.63	882.65
Concentrating plant		1,663.23			11,356.35	13,019.58
Concentrate house	76.80	449.69	354.80	623.27	602.10	2,106.66
Dorr thickeners		11,297.98			15,034.53	26,332.51
Circulating system		147.81			6,846.05	6,993.86
Air agitation	261.71	3,987.80			25,257.89	29,507.40
Clarifying		1,829.63			8,573.87	10,403.50
Precipitation system	395.00	44.05			29,581.02	30,020.07
Briquetting plant					1,589.49	1,589.49
Air compressor		1,084.39			7,094.52	8,178.91
Filter plant		4,456.68			30,104.50	34,561.18
Refinery	2,473.84	1,552.23	2,200.17	2,292.80	7,548.79	16,067.83
Boiler plant and fuel-oil system	571.56	90.97	401.25	531.11	7,606.28	9,201.17
Tank-heating system		9.56			3,362.39	3,371.95
Transformer house	91.83	101.05	428.69	213.07	4,804.89	5,639.53
Lime house	11.00			753.30	305.85	1,070.15
Machine shop	1,297.66	843.01	1,138.73	1,191.93	339.36	4,810.69
Storeroom	511.55	1,509.60	1,305.84	1,315.78	152.04	4,794.81
Inclined railway	133.25		432.70	203.41	379.51	1,148.87
Mill building	39,645.45	6,757.60	45,493.48	19,607.14	9,020.51	120,524.18
Total	$51,795.78	$51,085.37	$55,758.13	$30,861.38	$275,688.41	$465,189.07

of ore, of which 0.386 lb. is consumed and the balance discarded. Average service for cam shafts has been 27,214 tons stamped.

Thermit welding of cam shafts has been tried at a cost per shaft of $42.53.

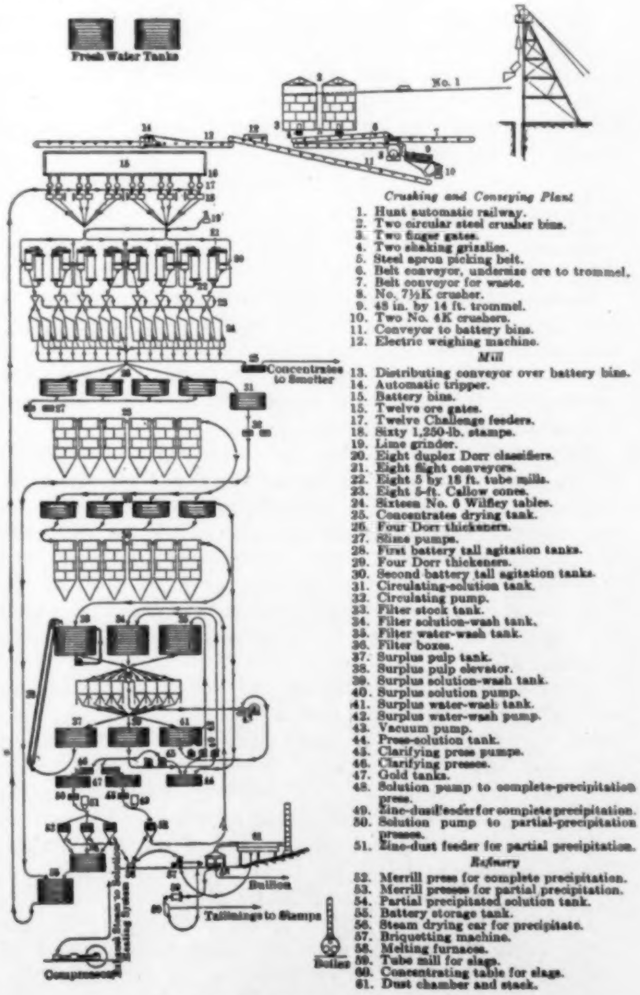

FIG. 1—FLOW-SHEET OF BELMONT MILL

Lime is added at the tube-mills in the form of milk of lime, and about one-half the total quantity of lead acetate used is also added here. About 75 per cent of the pulp is ground to minus 200-mesh size. The cost of silex lining was $395.84. It had a life of eight months, grinding 15,533 tons of ore. The cost of this lining per ton reground was $0.0583; per ton of ore milled, 0.048. With Komata manganese steel lining the cost per ton reground was $0.0457. The Belmont type of ribbed lining made of hard white iron has shown a service of nineteen months, and a cost of but $0.0346 per ton reground.

It is estimated that this lining will last two years and show a cost of but $0.0173 per ton reground. Danish pebbles are most economical.

A simple and accurate method of figuring return tonnage from tube-mill to classifier, in accordance with the accompanying table of screen analyses, is as follows:

Mesh	Battery Discharge		Tube-Mill Feed		Tube-Mill Discharge		Dorr Overflow	
	Per Cent	Cumulative, per Cent	Per Cent	Cumulative, per Cent	Per Cent	Cumulative, per Cent	Per Cent	Cumulative, per Cent
+ 10	10.3	12.3	5.4	5.4	....	.....	....	.....
+ 14	10.0	20.3	5.2	10.6	....	.....	....	.....
+ 20	10.2	30.5	5.3	15.9	....	.....	....	.....
+ 28	11.3	41.8	5.9	21.8	....	.....	....	.....
+ 35	7.7	49.5	4.9	26.7	1.0	1.0	....	.....
+ 48	7.1	56.6	6.5	33.2	3.1	4.1	....	.....
+ 65	5.6	62.2	8.1	41.3	6.5	10.6	....	.....
+100	6.0	68.2	20.0	61.3	20.0	30.6	1.0	1.0
+150	6.6	74.8	24.4	85.7	28.6	59.2	12.5	13.5
+200	4.0	78.8	7.8	93.5	12.7	71.9	14.2	27.7
−200	21.2	100.0	6.5	100.0	28.1	100.0	72.3	100.0

Tons crushed per day, 500. Feed per mill, 62.5 tons.

In the battery discharge there was 41.8 per cent., or 26.12 tons, which did not show in the tube-mill discharge. This material was represented in total tube-mill feed by 21.8 per cent. As we know this 21.8 per cent is represented by 26.12 tons, 100 per cent of the feed amounts to 119.8 tons.

Total feed, tons	119.8
Initial feed, tons	62.5
Return feed, tons	57.3
Ratio of return to initial feed	0.92 to 1

Concentration is practiced mainly for the purpose of removing only the heaviest and most refractory mineral. This gives a clean product but not a close concentration. For the fiscal year ended Feb. 28, 1915, concentration represented 0.67 per cent by weight and 11.5 per cent in extraction of the precious metals.

Pulp thickening is done in Dorr continuous thickeners, and agitation in tanks of the Pachuca type. Originally only 5.5 sq. ft. of settling area per ton of ore was allowed, but owing to changes in the ore this has had to be increased. Trays introduced into the Dorr thickeners increased the settling area to 8.47 sq. ft. They have given no serious troubles and have increased the capacity of the two thickeners in which they were installed about 75 per cent.

After continuous agitation the pulp is thinned by adding barren solution, and again thickened and agitated. This removes a large portion of the dissolved gold and silver and relieves the filters of this work. Solutions are heated to about 90 deg. Fahr. by steam coils placed in the air-lifts of the agitators. Extraction is improved about 2 per cent by use of warm solutions. The agitators are 15 ft. by 45 ft., and require 67½ cu. ft. of free air per minute at 30 lb. pressure.

A 250-leaf vacuum filter plant, constructed on the half-gravity system, is used for final displacement of solution from slime. Precipitation is by zinc dust. Only enough solution is completely precipitated to make the final barren-solution wash at the filters. The balance is precipitated to a value of 10 cents per ton and used in diluting at Dorr thickeners, tube-mill feed solution and for table wash. Zinc consumption is 0.7808 oz. per ounce of bullion. Precipitate is briquetted with 2.45 per cent borax, 6.05 per cent soda and 6 per cent sand and melted, the bullion averaging 93.23 per cent gold and silver.

Extraction is 96.2 per cent of the gold and 93 per cent of the silver.

The accompanying table shows the dissolution of gold and silver through the different steps in the process:

	Assays			Per Cent of Extraction in Each Department			Per Cent of Total Extraction in Each Department		
	Au	Ag	Value	Au	Ag	Total	Au	Ag	Total
Battery heads	0.32	32.1	$25.66	...	...	....	...	...	....
Battery discharge	0.21	30.4	22.44	...	...	....	...	...	....
Extraction in battery	...	...	....	34.4	5.3	12.5	34.4	5.3	12.5
Battery discharge	0.21	30.4	22.44	...	...	....	...	...	....
Dorr classifier overflow	0.08	27.1	17.86	...	...	....	...	...	....
Extraction in tube mills	...	...	....	62.0	10.8	20.4	40.7	10.28	17.9
Classifier overflow	0.08	27.1	17.86	...	...	....	...	...	....
Table tailings	0.06	24.2	15.72	...	...	....	...	...	....
Extraction by concentration	...	...	....	25.0	12.0	8.9	6.0	9.0	8.34
Table tailings	0.06	24.2	15.72	...	...	....	...	...	....
Agitator heads	0.05	21.2	13.72	...	...	....	...	...	....
Extraction lower thickeners	...	...	....	16.6	12.4	20.0	3.1	9.33	7.8
aAgitator heads	0.054	18.9	12.42	...	...	....	...	...	....
aNo. 6 agitator	0.02	4.85	3.31	...	...	....	...	...	....
Extraction first six agitators	...	...	....	60.0	74.3	73.3	9.4	50.99	40.57
aNo. 6 agitator	0.02	4.85	3.31	...	...	....	...	...	....
No. 7 agitator	0.015	4.2	2.82	...	...	....	...	...	....
Extraction upper thickeners	...	...	....	25.0	13.3	14.8	1.2	2.0	1.9
No. 7 agitator	00.15	4.2	2.82	...	...	....	...	...	....
aFilter stock	0.014	2.8	1.96	...	...	....	...	...	....
Extraction second six agitators	...	...	....	6.6	33.3	30.5	0.3	4.3	3.3
aFilter stock	0.014	2.8	1.96	...	...	....	...	...	....
aFilter discharge	0.01	2.3	1.58	...	...	....	...	...	....
Extraction in stock tank and filters	...	...	....	28.6	18.0	10.3	1.25	1.56	1.48

aSamples are averages for 30 days, taken from assay records. Silver figured at 60c. per ounce for values.

Milling Costs for the Fiscal Year 1914-15, per Ton of Ore Treated

	Labor	Supplies	Power	Total
Crushing and conveying	$0.036	$0.020	$0.010	$0.068
Stamping	0.056	0.155	0.096	0.307
Classifying	0.014	0.002	0.006	0.022
Tube milling	0.032	0.102	0.230	0.364
Thickening	0.024	0.028	0.003	0.055
Concentrating	0.028	0.042	0.008	0.078
Agitating slime	0.050	0.764	0.007	0.821
Filtering and discharging	0.061	0.083	0.027	0.171
Precipitation	0.028	0.086	0.020	0.134
Assaying	0.009	0.005	0.000	0.014
Refining	0.017	0.024	0.002	0.043
Lighting	0.001	0.001	0.008	0.010
Shift bosses	0.036	0.000	0.000	0.036
Watchman	0.012	0.000	0.000	0.012
Surface and plant	0.015	0.006	0.000	0.021
Totals	$0.419	$1.318	$0.419	$2.156

Segregation of Supplies Used

	Quantity per Ton	Cost per Ton
Hydrochloric acid	0.17 lb.	$0.0078
Belting	....	0.00336
Cyanide	3.52 lb.	0.601
Conveyor parts	....	0.0004
Crusher parts	....	0.0126
Lead acetate	0.366 lb.	0.033
Laboratory supplies	....	0.003
Lime	5.47 lb.	0.041
Fuel oil	2.5 gal.	0.100
Pump parts	....	0.011
Pebbles	4.16 lb.	0.057
Tube-mill lining	....	0.023
Zinc	0.952 lb.	0.072
Refinery fluxes	....	0.008
Battery shoes	0.287 lb.	0.0135
Battery dies	0.271 lb.	0.0148
Water (other than mine)	....	0.165
Miscellaneous	....	0.14254
Total	....	$1.318

Cyanide Practice of Churchill Milling Co.—The mill of the Churchill Milling Co. is situated at Wonder, Nev., 55 miles from Fallon, the nearest railroad point. Operations for the year ended Sept. 30, 1914, were described by E. E. CARPENTER in a paper before the American Institute of Mining Engineers in San Francisco. A flow-sheet is given in Fig. 2.

The ore treated is an unusually tough and hard oxidized quartz containing a small quantity of sulphides, rich in both gold and silver. The mill is built on a 30 deg. slope, and contains equipment in the following order:

1, 10 by 16 in. Blake crusher.
10, 1,400-lb. stamps.
1, 6 ft. Trent Chilean mill.
1, Dorr duplex classifier.
1, 5 by 22 ft. tube mill.
1, 24 by 14 ft. Dorr thickener.
4, 15 by 45 ft. Pachuca-type agitators.
1, 28 by 10 ft. Dorr thickeners.
1, 28 ft. by 14 ft. stock tank with stirrer.
2, 8 by 11 ft. 6 in. Oliver filters.
5, Zinc boxes.
2, Melting furnaces.

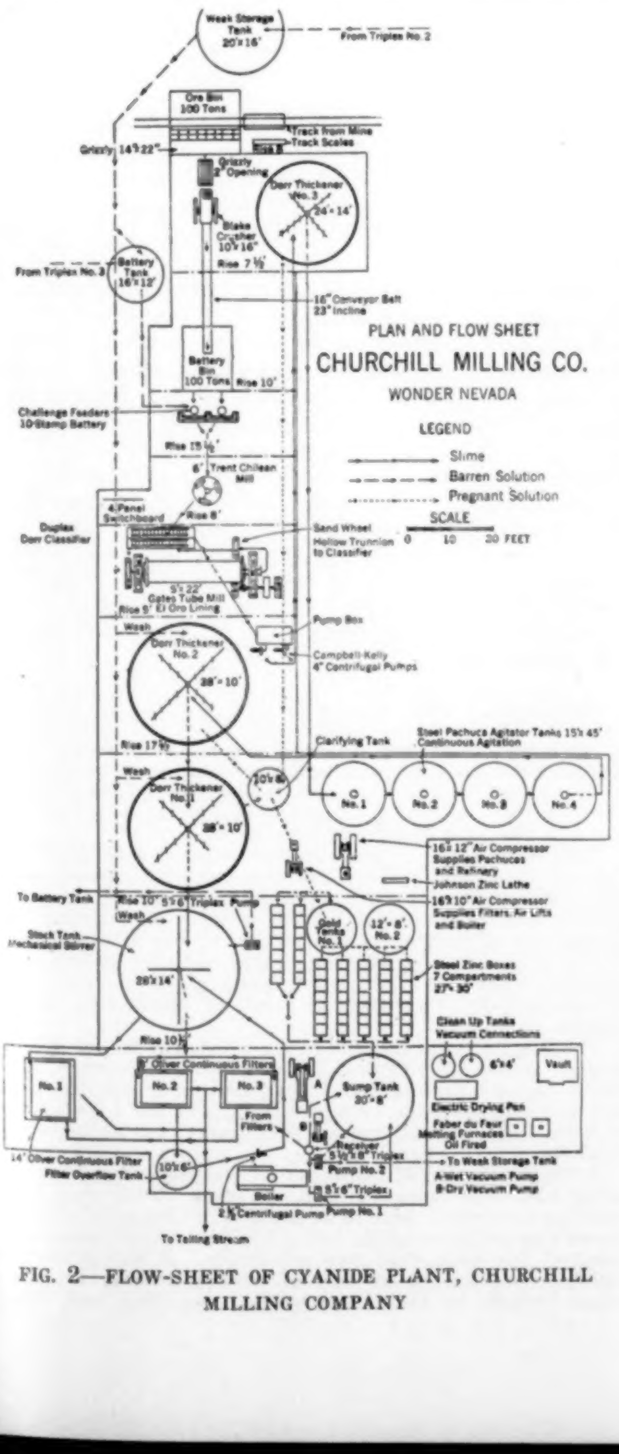

FIG. 2—FLOW-SHEET OF CYANIDE PLANT, CHURCHILL MILLING COMPANY

The annual report for 1914 shows a gold recovery of 95.1 per cent and a silver recovery of 92.4 per cent, or 93.2 per cent of the gross value. The average value of mill feed was 0.216 oz. gold and 19.48 oz. silver per ton.

TABLE I.—TONNAGE, COST AND RECOVERY DATA

Months	Tons per Month	Tons per Day	Total Direct Cost	Cost to Date	Gold Recovery, per Cent	Silver Recovery per Cent	Value Recovery, per Cent
Oct., 1913	4,160	134.2	$2.825	$2.825	95.3	92.8	93.6
Nov., 1913	4,032	134.4	2.852	2.838	94.2	92.9	93.7
Dec., 1913	4,103	132.4	2.812	2.830	94.3	93.4	93.7
Jan., 1914	3,357	108.3	3.189	2.906	95.2	92.1	92.5
Feb., 1914	3,254	116.2	2.861	2.898	93.8	93.6	93.7
March, 1914	4,350	140.3	2.567	2.836	94.8	93.7	93.9
April, 1914	3,730	124.3	2.604	2.804	95.3	92.2	93.1
May, 1914	4,217	136.0	2.598	2.777	94.3	91.1	91.2
June, 1914	4,200	140.0	2.521	2.746	95.6	89.4	91.7
July, 1914	4,392	141.7	2.781	2.750	96.3	90.6	92.1
August, 1914	4,440	143.2	2.657	2.739	97.3	93.4	94.3
Sept., 1914	4,335	144.5	2.771	2.743	97.3	92.7	94.0
Averages or totals	48,570	133.1	2.743	2.743	95.1	92.4	93.2

Stamps weighing 1400 lb. crush through 3/8-in aperature. Using chrome steel shoes and dies the consumption of steel per ton of ore ground was: Shoes, 0.232 lb; dies, 0.107; total, 0.339 lb.; cost per ton, $0.018.

In a Trent 6-ft. Chilean mill the average consumption of chrome steel was 0.5 lb. per ton of ore ground, costing $0.034. El Oro lining in a 5-ft. by 22-ft. Allis-Chalmers tube-mill cost $0.022 per ton ground, based on twelve months' operation with the liners still in use and worn practically smooth, with a prospect of three months' more use. Consumption of pebbles was 3.39 lb., costing $0.08 per ton of ore ground.

On an average tonnage of 133 per day, a 14-ft. by 24-ft. Dorr thickener takes care of the entire flow, giving 3.4 sq. ft. of settling area per ton of ore thickened.

Silver goes into solution very readily. Part of the lime and lead acetate is added at the Challenge feeders and the balance at No. 1 agitator. Sodium cyanide is added at No. 1 agitator.

The following table gives average extractions as obtained at different points in the process:

	Extraction in Tanks		Total Extraction	
	Gold, per Cent	Silver, per Cent	Gold, per Cent	Silver, per Cent
Up to No. 1 agitator	....	....	76.5	72.2
Disch. from No. 1	9.7	11.5	86.2	83.7
Disch. from No. 2	4.6	5.0	90.8	88.7
Disch. from No. 3	2.8	2.8	93.6	91.5
Disch. from No. 4	0.9	1.2	94.5	92.7
Filter	1.4	0.5	95.9	93.2

A saving of 0.23 lb. of cyanide was made by changing the method of washing the cake on the Oliver filter, using water on both ascending and descending sides, instead of barren solution on the former and water on the latter. In order to prevent excessive dilution of solution by this double use of water, a rubber apron is placed against the cake on the ascending side to divert the surface water to the slime-discharge launder. Similarly on the descending side an iron apron 18 in. wide was placed so that its upper edge was just above the blow-off section. This apron scraped off about 1/16 in. of the cake surface and removed considerable wash water, diverting the pulp to the usual discharge launder without interfering with the regular operation of the blow-off. This method makes it possible to keep the cake covered with a sheet of water on both sides without allowing an excessive amount to enter mill solution. Sampling and assaying of filter tailings shows a loss of

0.85 lb. cyanide per ton of ore, and a loss of soluble gold and silver of \$0.18 per ton of ore.

Precipitation on zinc in boxes shows an average efficiency of 95.2 per cent, the average value of head and tail solutions being \$2.227 and \$0.107 respectively. The precipitate is refined without acid treatment; it is dried and mixed with 7 per cent each of the following fluxes: Borax glass, soda and sand.

Lead

Lead Smelting at El Paso.—A paper by H. F. EASTER, assistant superintendent of the El Paso Smelting Works, El Paso, Tex., was presented at the San Francisco meeting of the American Institute of Mining Engineers, describing the plant and practice in the lead-smelting department. Lead-ore supply in recent years has been precarious, with a general tendency toward excess of silica and shortage of iron. To supply the latter a considerable amount of roasted leady copper matte from Chihuahua and converter matte from El Paso have been used. These materials, together with complex lead-copper ores from Arizona, have introduced an unusual amount of copper into the plant and have had an important bearing on the smelting practice.

Unloading is done by contract at rates based on the character of the car and the distance to which the ore must be wheeled. When the initial sampling is done by hand the rates include the cutting of the sample and wheeling it to the sample storage platform. An extra allowance is made for spreading the ore in the bin itself, as this must be done carefully by hand because of the different character of the numerous small lots which are bedded together. Hand sampling is done by taking every tenth shovel of the fines and setting aside the coarse lumps, from 6 in. up, for automatic sampling. The automatic plant contains the usual sampling equipment. The automatic sample is added to the hand-cut sample of fines, and the combined sample is then put through a smaller automatic sampling equipment. A sample from one car amounts to from 400 to 500 lb. It is circled, coned and quartered by hand until reduced to proper size for the bucking room. In the case of high-grade ore the whole lot is sampled automatically. Concentrates are shovel-sampled.

All ores requiring roasting are bedded. In general the best results are obtained when the mixture contains 20 per cent silicious sulphides with leady copper matte. Three Godfrey 30-ton roasting furnaces are used for the preliminary roast. Two are oil-fired and consume 0.22 bbl. of oil per ton roasted; the coil-fired furnace consumes 0.11 ton of coal per ton roasted, all of which, however, is not chargeable to roasting, as some half-burned material is drawn off for the Huntington-Heberlein pots. The pots handle two charges of 6 to 7 tons in twenty-four hours. Air pressure for the pots is 10 oz. The fine material in the sintered product amounts to from 5 to 10 per cent of the charge, and is added to the next charge. Sulphur in the final product averages about 5 per cent.

The hearth area of the blast furnaces at the tuyeres is 46 in. by 162 in. The average capacity is about 180 tons of charge per furnace day, although with a coarse charge it has frequently been better than 200 tons. Production of flue dust averages from $1\frac{1}{2}$ to 2 per cent of the charge smelted. The flue system is 800 ft. long, of which the first 375 ft. is provided with hoppers that collect the greatest part of the dust. These hoppers are discharged into tram cars. The flue dust is briquetted with 10 per cent burned lime, and the briquets are allowed to dry for from three to six weeks.

The author devoted considerable attention to the difficulties experienced at El Paso in settling and separating leady copper matte from the slag, as this problem has been most vexing at the El Paso plant. Originally this operation was accomplished in a Rhodes separator, or small reverberatory furnace. This was satisfactory in the days of large lead tonnage, but has proved unsatisfactory with the present small tonnage of lead ores. These furnaces are now permanently abandoned. Experiments with small settlers in front of the furnaces were not satisfactory, as they tended to fill with zinc mush that seriously interfered with settling of matte. This condition was finally remedied by changing the charge so as to use less of the Huntington-Heberlein roast, and since that time similar troubles have been overcome by changes in the furnace and roaster charges.

The latest arrangement of settling devices is to have a rectangular box in front of and at an angle of 45 deg. with each furnace, and a large, oil-fired settler to serve each two furnaces. The furnace is connected with the rectangular box and the box with the settler by short water-coil spouts. The boxes are lined with magnesite brick all around. The settler measures 10 ft. by 20 ft. and is supported on rails running crosswise. Air spaces are provided beneath the bottom pan to keep seeping lead from progressing downward into the foundation. The sides and ends are lined with magnesite brick. A matte tap is provided on each side close to the front and a single lead tap in the middle at the rear end. Every effort is made to prevent lead getting into the settler, as experience with the Rhodes settler had shown the inadvisability of keeping a bath of molten lead in contact with matte. The settler requires about 7 bbl. of oil per day.

The Salida Smelter.—A description of the plant and lead-smelting practice at the plant of the Ohio & Colorado S. & R. Company, at Salida, Col., by F. D. WEEKS, was presented at the San Francisco meeting of the American Institute of Mining Engineers. Some of the most interesting points in the paper are those relating to errors in construction and early operation. This smelter was one of the first to make a commercial installation of the Dwight-Lloyd sinter-roasting process, a description of which appeared in this journal, February, 1912. One of the results of the use of this process was to increase the capacity of a 48-in. by 180-in. blast furnace from 180 to 250 tons per day. Speaking of some of the peculiarities of construction of the original plant, the author says:

> Originally, a brick wall, with a narrow door in front of each blast furnace, was constructed. How the work was to be done behind this wall is not known, but it shows that the designer did not know how to do the work.
>
> The water jackets were held in place by a 12-in. I-beam running the length of the furnace, thus effectually preventing any one from examining a tuyere or jacket.
>
> The shaft walls on the feed floor were so thick that the feeders were shoving ore into one end of a tunnel, and, since the opening was not as wide as the shaft, the ends of the furnace could not be fed except by throwing the charge around a corner which, of course, was not done.
>
> The proposal to concentrate matte carrying 20 per cent lead and 5 per cent copper, in a copper-matting furnace was intended to do away with the necessity of roasting equipment.
>
> The largest Corliss engine on the plant was the exhibition engine at one of our world's fairs held some years ago. When repairs were needed, it was discovered that this was the only engine of the kind ever built, and the drawings of it were lost; so each repair part called for an accurate drawing.
>
> In the track plan of the works, all the ore, coke, and limestone had to be unloaded from one track. This track also held the cars which were to be unloaded at the oxide crusher as well as at the sulphide mill. The problem of dispersing some of this congestion was not simple. It was solved by building two trestles in place of one; by having the limestone brought in dump cars so that unloading took little

time; and by building an oxide crushing and screening plant on new tracks.

Referring again to the Dwight-Lloyd sintering plant, an important improvement has been made by placing an adjustable rail by the side of the pallets so that the weight of the pallets and their charge is carried on rollers and no dragged across the top of the wind box.

Recent Chemical and Metallurgical Patents

Electrolytic Processes

Caustic Soda and Chlorine.—An electrolytic cell of concrete for the production of caustic soda and chlorine is patented by Messrs. EDWARD A. ALLEN and HERBERT I. ALLEN of Maine (assigned to the Electron Chemical Company, Portland, Me.). Fig. 1 shows a perspective view of the cell and Fig. 2 a cross section. The cell consists of a main body containing the anodes 50, held by carbon rods 31, supported at the top of the cell. These carbon rods pass through the elliptical openings 17, which are made that shape to allow for the upward passage of the chlorine gas. The main body of the cell which comprises the anode chamber is open at its opposite ends, and against these open ends are placed the cathodes 20, held in place by clamps. The trough 15 is provided for catching the caustic soda solution which trickles down the cathodes. It may be drawn off through opening 16. The opening 30 is provided for introducing the brine solution. The cell may be made in two parts, one part consisting of the bottom and end pieces 11, and the other part the top piece with the anode openings, provided with a sliding connection. As it is only the cell which is patented the manner of operating or material of which the anodes and cathodes are made is not stated. (1,148,274, July 27, 1915.)

Caustic Soda and Chlorine.—A diaphragm cell for caustic soda and chlorine production is patented by Mr. HARRY R. NELSON of Elizabeth, N. J. This cell is shown in Fig. 3 in which 1 represents the outer casing which serves as a support at 3 and 4, for the cell proper 2. The cell proper contains the diaphragm 5 of asbestos and the cathode 6 and anodes 7, below the dome chlorine chamber 9 of slate or other non-conducting material. The cathode 6 of perforated iron is pressed against the outside surface of the diaphragm. The outer casing is made gas-tight at the angle 13, and the inlet pipes 14, 15 are provided for supplying steam, which is controlled by the valves 16. Outside of the cathode are screens 17 and 18 held in place by the strips 20. The removable strips 21 are provided for catching any solid matter. In the operation of the cell sodium chloride solution is supplied from the top through a pipe between the cathodes, the evolved chlorine is collected in chamber 9, and discharged through opening 28. "The cation sodium encounters the steam supplied through the inlet pipes 14, 15 and forms caustic liquor of high concentration, with the evolution of hydrogen." The pressure of the steam at the inlet pipes 14, 15 is such as to maintain a "faint" cloud within the casing 1. The evolved hydrogen passes upward along the outer side of the cathode 6 and is discharged. The caustic liquor formed trickles down the outside of the cathode 6, and is caught in the tilting pan 22, which empties into the larger pan 23, provided with the discharge 25. Dry steam is preferably used and for this purpose the trap 31 is provided. The use of steam is claimed to give greater efficiency of production. (1,149,210 and 1,149,211, Aug. 10, 1915.)

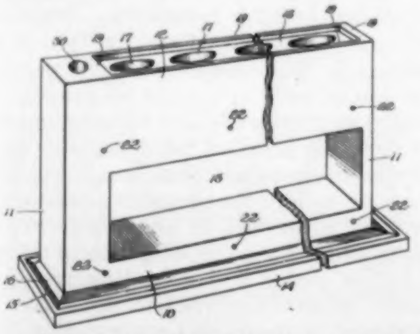

FIG. 1—ELECTROLYTIC CELL FOR CAUSTIC SODA AND CHLORINE

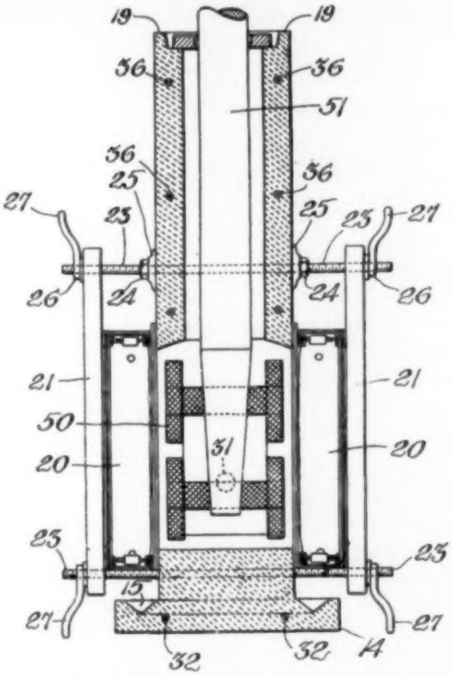

FIG. 2—CROSS-SECTION OF ELECTROLYTIC CELL FOR CAUSTIC SODA AND CHLORINE

Caustic Soda and Chlorine.—An electrolytic cell of the bell type ("gravity cell") is patented by Mr. HENRY CHARLES JENKINS of London, England. In this cell

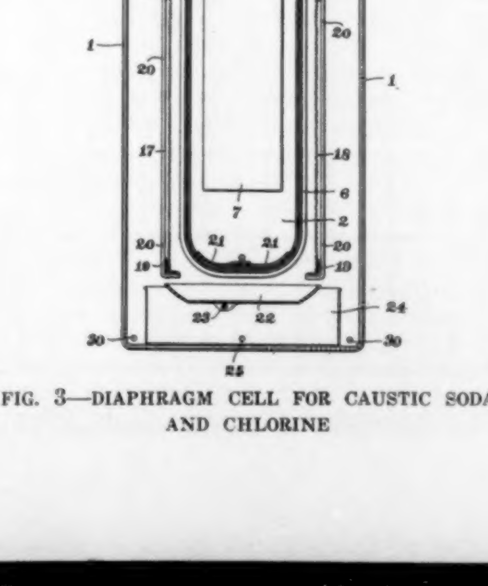

FIG. 3—DIAPHRAGM CELL FOR CAUSTIC SODA AND CHLORINE

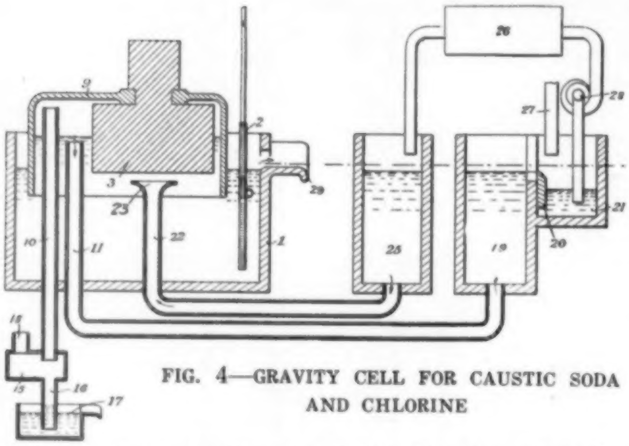

FIG. 4—GRAVITY CELL FOR CAUSTIC SODA AND CHLORINE

which is shown in Fig. 4, a bell 9 dips down into the casing 1, the bell being open at the bottom. The anode 3 is fastened to the bell by an air-tight connection. The cathode 2 is arranged as shown and may be made in any suitable manner so as to provide for the removal of gases formed thereon. For introducing fresh brine solution pipe 22 is provided, connected to tank 25, the fresh solution being delivered directly beneath the anode. For conducting solution away and thus circulating the electrolyte, pipe 11 is provided, connected to tank 19 which has an adjustable weir 20. In this manner the liquid in the cell may be kept at any desired height. At 28 is indicated a pump for circulating the electrolyte and at 26 a heating apparatus. Fresh brine solution may be introduced in 21 by pipe 27. For conducting away the chlorine gas formed in the bell, pipe 10 is provided, connected to a device for separating any liquid from the gas at 16. The caustic soda solution overflows at 29. (1,150,370, Aug. 17, 1915.)

Improvements in Electrolytic Copper Refining.—A patent for a new method of handling the solutions in electrolytic refining has been granted to Messrs. Francis R. Pyne and Henry M. Green and assigned to the U. S. Metals Refining Company of Chrome, N. J. In the usual electrolytic copper refining process, the solution is circulated by introducing and withdrawing the liquid to provide an even distribution. The solution withdrawn from the tank is then treated in a second tank or series of tanks to recover more of the copper, before treating the solution further to recover secondary constituents known as impurities. In this second treatment it is necessary to use insoluble anodes and consequently a higher voltage and more energy. The deposit in the second electrolysis is usually inferior to the first deposit. The solution after second treatment is then used to recover the secondary constituents.

The present patent proposes to utilize the fact that solutions stratify when the current is passing, and to allow the solution to stratify, withdrawing same from different levels. In this manner the solutions withdrawn may be regulated so that the primary solution is sufficiently strong in copper to be led into a second tank, where it is treated same as before, while the secondary

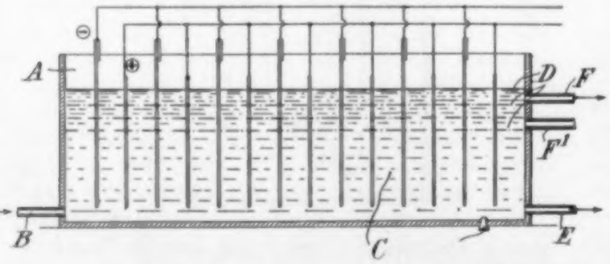

FIG. 5—ELECTROLYTIC COPPER REFINING TANK

solution is so poor in copper that it may be directly treated for recovery of the secondary constituents. This effects a saving in power owing to the elimination of the insoluble anode treatment. In Fig. 5, a tank is shown with entry for solution at *B*. It was found that the copper solution was purest on the lower level at *C*, and the concentration of impurities greatest at the upper level *D*. *E* is a pipe for withdrawing primary solution for second tank and *F* and *F'* pipes for withdrawing solution rich in impurities. A certain amount of circulation is necessary but is not usually as rapid as in the old process. The process produces a greater output of merchantable product than heretofore by enabling the series of tanks to operate under conditions similar to the first series, effecting a saving in electrical energy. (1,148,798, Aug. 3, 1915.)

Regenerating Electrolyte in Copper Refining.—A process for purifying the sulphuric acid electrolyte used in copper refining and for recovering arsenic contained in it is patented by Oliver Curtis Martin and Frederick Jaeger of Perth Amboy, N. J. The electrolyte is first nearly freed from copper by electrolyzing with an insoluble anode or by evaporation and crystallization or both. It is preferred to remove as much copper as possible with the insoluble anode. After removing the copper one method is to evaporate the solution until it contains 74 per cent sulphuric acid, and then boil with charcoal by which some of the sulphuric acid is reduced to sulphurous. The latter attacks the arsenic acid reducing it to arsenious. Carbonic acid is liberated. The solution is then diluted to 38 per cent sulphuric acid and allowed to cool, causing the arsenious acid to be precipitated. This method is preferably used when the copper is removed by evaporation.

Another method which is preferably used where the copper is removed by electrolysis is to subject the solution to sulphurous acid gas and concentrate or dilute to 38 per cent, when upon cooling the arsenious anhydride separates out, which may be purified by sublimation giving a marketable product.—(1,148,522, Aug. 3, 1915.)

Method of Cleaning Articles.—A process for removing tarnish and stains from silverware and other metals is patented by Mr. Elbert L. Couch of Hartford, Conn. (assigned to the Couch-Dean Corporation, of the same place). In this process the articles to be cleaned are placed on a traveling belt having a surface of tin or aluminium and sprayed by suitable means with an electrolyte. In this manner a short-circuited couple is formed and the oxide tarnishes are reduced to metal. The apparatus in which the cleaning is carried out is essentially the same as that in patent 1,068,568, July 29, 1913, granted to Mr. Couch and the electrolyte used, termed "silverease" was also patented by him in patent 674,254 of May 14, 1901. (1,150,101, Aug. 17, 1915.)

Electric Furnaces

Manufacturing Articles from Silica, Magnesia, Etc.—In a process patented by Prescott M. Hulbert of Detroit, Mich., finely divided refractory material such as silica is compressed in a mold of graphite and the mold is heated in an electric arc furnace to a temperature near the fusing point of the material. This causes the particles to integrate and form a solid compact form, the shape of the mold. No binder is necessary and the integration may be carried to any degree according to the heat employed. An artificial graphite cylinder may be placed in the center and extending nearly through the mold, and connected to electric terminals. The refractory material is inside and surrounding this cylinder and thus a means is provided for further heating of the material. A certain amount of shrinkage will occur,

which will, however, be lessened by using finely ground material.—(1,155,358, Oct. 5, 1915.)

Manufacture of Pure Carbon.—Pure carbon can be made from tar oils or other hydrocarbons for use in the manufacture of electrodes or other electrical conductors according to a patent of HENRI HENNEBUTTE of Paris, France (assigned to Société Anonyme des Combustibles Industriels of Paris, France). In this process the hydrocarbon to be used is left standing, or is filtered to remove any mineral dust. It is then passed either in a liquid or gaseous state into a still from the top. A steam coil in the still heats the oil and air is forced in to dehydrogenate the mass. A solvent such as benzine is then admitted and the dissolved portion is led away at the bottom through a pipe to another still. The insoluble oxidized mass of material which has been dehydrogenated is then heated further until it is thoroughly carbonized. The material in the second still may be distilled and the residue treated in the first still. The temperatures used in all cases depend on the raw materials used.—(1,155,419, Oct. 5, 1915.)

Reduction of Zinc Oxide in an Electric Furnace.—A process for the production of pure zinc from oxide or blue powder is patented by FRANK WILLIAM HIGHFIELD of Caversham, England. The oxide is fed into a furnace from the top, onto a bed of coke which forms the resistor for the furnace. The coke is heated to redness by the current and forms an atmosphere of carbon monoxide which together with the glowing carbon reduces the oxide to metal. The metal is condensed and trickles down through the coke and is led through a cooling chamber in which oxygen is excluded and is then discharged. The temperature should be about 1050 deg. C. A cross-section of the furnace is shown in Fig. 6. The oxide is fed in at *C* by the conical feed and passes through the tube *D* which is of fireclay so as to be porous to carbon monoxide. The bed of coke rests on bars *F* and is in contact with the electrodes *E*. The tube *D* is intended to provide a condensing surface. The condensed metal is caught at *A*, and led through the cooling chamber. The advantages of this method are claimed to be that it gives a large condensation surface which is necessary on account of the low vapor pressure of the metal and, by starting with the oxide instead of treating zinc ores direct for the recovering of pure zinc many difficulties are overcome.—(1,153,786, Sept. 14, 1915.)

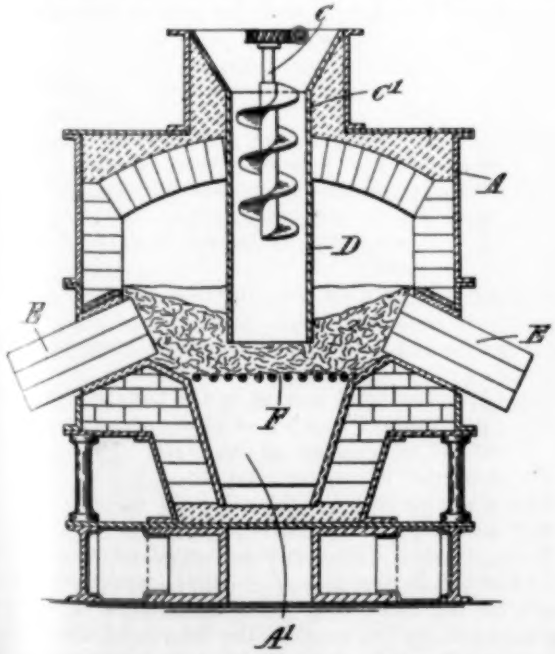

FIG. 6—ELECTRIC ZINC FURNACE

Chemical Engineering

Apparatus for Distillation of Peat.—In order to extract valuable ingredients from peat and produce coke a distillation apparatus has been patented by ELLIS BARTHOLOMEW of Toledo, Ohio (assigned to the National Peat Refining Company, Cleveland, Ohio). In this apparatus peat is fed from a closed bin 1 by a screw conveyor 4 to a cylinder called a separator shown in Fig. 7 at 10. The bottom of this separator is made hopper-shape and directs the peat on to a grate of electrically heated resistance bars 23. The heat of the bars drives off the gases from the heat converting it into coke. The gases pass up and out through openings 39 and the coke is shaken through the grate by suitable means, dropping into another conveyor, whence it is led to a bin. The separator and peat bin are kept full of the gas from the peat, so as to exclude air. For this purpose a reservoir of the gas is connected to valve 41. The gases which pass out through 39 are passed through suitable condensers where the lighter and heavier liquids are obtained.—(1,156,387, Oct. 12, 1915.)

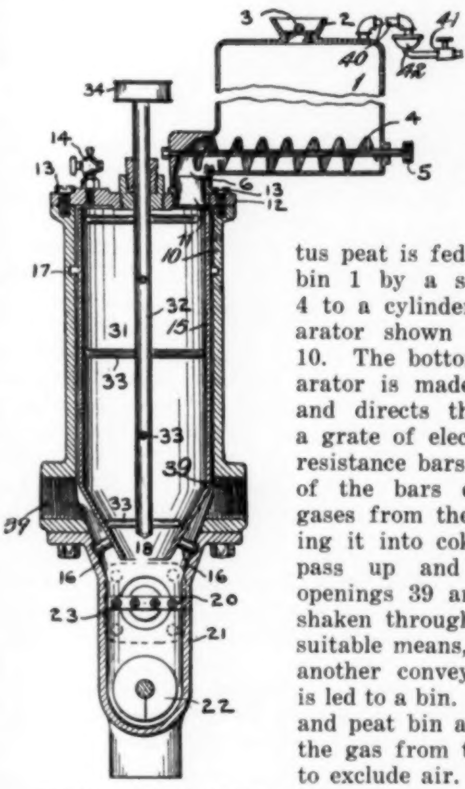

FIG. 7—DISTILLATION OF PEAT

Iron and Steel

Manufacture of Steel.—In adding the necessary additional elements to refined molten iron for making steel it is claimed to be advantageous if the additions are first dissolved in a separate subsidiary bath of refined iron and then this separate bath added to the main bath of refined iron in the casting ladle where they become mixed together. A patent which comprises these features has been granted to JEGOR ISRAEL BRONN of Rombach, Germany (one-half assigned to Rombacher Hüttenwerke, Rombach, Germany). The dissolving furnace is charged with molten refined iron which is usually available in steel works and then the desired additions such as carbon, manganese, silicon, titanium, etc., are made either in the pure state or as ferro-alloys. This gives an exact method of making additions, whereas in making additions directly to the main bath, losses of carbon and other constituents occur through the slag and gasification. It also provides a means for making carbon steels almost free from manganese or manganese steels poor in carbon, which was more difficult by the old method because in spiegeleisen or ferro-manganese which were generally used the proportion between the contained manganese and carbon is almost fixed. Another advantage occurs when it is desired to add only very small amounts of a metal such as titanium or vanadium. In the old method the small amounts of added metal might not become thoroughly diffused

throughout the bath, while in this process the chance that they will is much greater since the original bath to which they are added is so much smaller.—(1,156,051, Oct. 12, 1915.)

Lead

Treatment of Carbonaceous Fuel for Metal Reduction Furnaces.—In a process patented by WILLIAM D. KILBOURN of Tooele, Utah, it is proposed to form a coating on the coke or other combustible material, for the purpose of preventing combustion in the zones of the furnace where it is undesirable. In shaft furnaces, by selecting a coating which melts at the right temperature, combustion of the fuel can obviously be made to take place at any point. In this manner hot-tops, wall accretions in the upper part of the furnace, and consequent heat losses at the top may be prevented. For lead blast-furnace practice it has been found that a good coating may be made from a mixture of lead sulphate, lead oxide and a varying percentage of impurities, the mixture to contain about 60 per cent lead. This makes a good pigment which sticks to the coke and protects it from the fire until it reaches the lower part of the furnace. Thus fuel of a size adapted to be charged into a blast furnace may be treated without briquetting.—(1,148,782, Aug. 3, 1915.)

Conveyor Belt Calculating Chart

At the San Francisco meeting of the American Institute of Mining Engineers, September, 1915, Messrs. J. D. MOONEY and D. L. DARNELL of the B. F. Goodrich Company, Akron, Ohio, presented the following chart and discussion.

The chart has been drawn for the convenience of engineers as a means of quickly determining the correct number of plies of conveyor belts operating under specific conditions.

The calculations are based on the average safe strength (factor of safety, 15) of the various standard rubber conveyor belts.

The calculations assume maximum loading conditions; that is, the belt is considered as carrying the greatest load that it will handle without spillage at ordinary belt speeds. This not only produces the most economical operating conditions, but also the maximum tension in the belt.

The chart is a graphical representation of the formula:

$$p = kgW(L + 10H)$$

Where p = the correct number of plies.
k = a constant, depending on the type of drive.
g = the weight in pounds per cubic foot of material handled.
W = the width of the belt in inches.
L = the length of the belt in feet (approximately twice the center distance).
H = the difference in elevation between the head and tail pulleys, in feet.

For a simple drive, with a bare pulley,

$$k = \frac{1}{250{,}000}$$

For a simple drive, with a rubber-lagged pulley,

$$k = \frac{1}{300{,}000}$$

For a tandem driver, with bare pulleys,

$$k = \frac{1}{375{,}000}$$

For a tandem drive, with rubber-lagged pulleys,

$$k = \frac{1}{455{,}000}$$

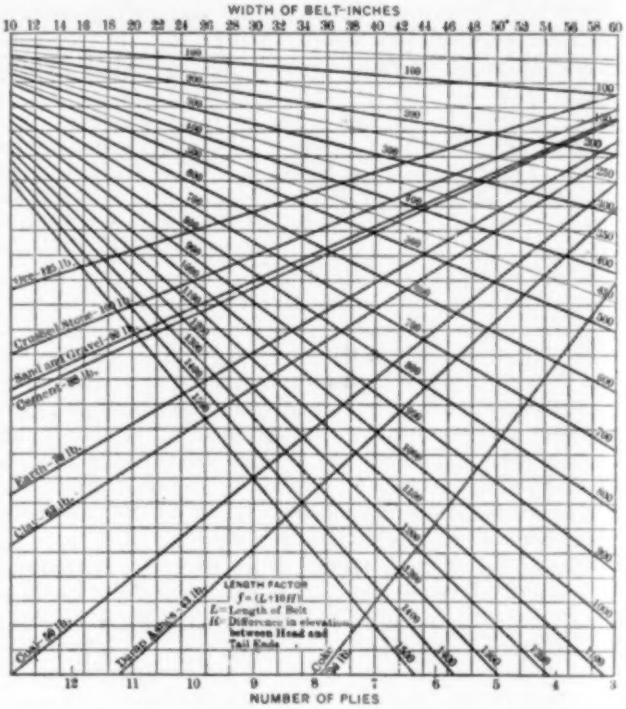

FIG. 1—CONVEYOR BELT CALCULATING CHART

The chart is drawn for a simple drive, with a bare pulley $\left(k = \frac{1}{250{,}000}\right)$; therefore, the number of plies obtained from the chart should be multiplied by the factor 0.83 or 5/6 for simple, lagged drive; the factor 0.67 or 2/3 for tandem, bare, and the factor 0.55 or 11/20, for tandem, lagged.

The formula $p = kgW(L + 10H)$ has been developed mathematically from the following formulas, which have been found to work very satisfactorily in average good practice:

$$U = \frac{0.08W^2Sg}{5000}$$

$$HP = \left(\frac{0.02l}{100} + \frac{0.01H}{10}\right)U$$

$$T = \frac{C \times HP \times 100}{S}$$

$$p = \frac{T}{24W}$$

Where U = Capacity in tons per hour,
W = Width of belt in inches,
S = Belt speed in feet per minute,
g = Weight per cubic foot of material handled,
HP = Horsepower developed in driving conveyor belt,
l = Length of the conveyor, in feet (approximately $\frac{1}{2}L$),
H = The difference in elevation between the head and tail pulleys, in feet,
T = The total tension in the belt, in pounds,
p = Correct number of plies,
C = The constant of the drive.

For a simple drive, bare pulley, $C = 600$
For a simple drive, rubber-lagged pulley, $C = 500$
For a tandem drive, bare pulleys, $C = 400$
For a tandem drive, rubber-lagged pulleys, $C = 330$

The length factor, $f = (L + 10H)$, represented on the chart by the lines 500, 600, 700, etc., is a developed factor equal to the sum of the length of the belt and ten times the difference in elevation between the head and tail pulleys.

To find the correct number of plies for a conveyor belt, knowing the width, the length, the difference in elevation between the head and tail ends, and the kind of material to be handled:

Start from the width given at the top of the chart and move down until this line intersects the line corresponding to the proper length factor; then move either right or left until the line corresponding to the given material is met; then move down again to the scale of plies, where the next largest figure will give the correct number of plies.

For example: To find the correct number of plies for a conveyor belt 36 in. wide and 300 ft. long, with 20 ft. difference in elevation, handling sand and gravel:

Follow the line from the 36-in. width downward until it intersects the 500 length factor line; then follow to the right until the sand and gravel line is intersected; then down to the ply scale, where the ply will be found to be 7.

New Portable Direct-Current and Alternating-Current Electrodynamometer Instruments

Problems hitherto considered impossible of solution have been solved in the design of the new electrodynamometer instruments of the Weston Electrical Instrument Co. of Newark, N. J. They are the latest development of instruments of this type and embody characteristics never before attained. There are four instruments of this type.

The portable electrodynamometer **wattmeter**, model 310, is adapted to measurements of precision on alternating-current or direct-current circuits and is guaranteed to an accuracy of 1/4 to 1 per cent of full scale value, either on direct or single-phase alternating-current circuits of any frequency to 133 cycles per second and any wave form. It can be used on circuits of any commercial frequency, even as high as 500 cycles per second, with very slight error due to phase displacement. Double ranges are provided for both current and voltage circuits. All current ranges can be used for 100 per cent overload indefinitely without introducing error.

The movable system has an extremely low moment of inertia and is very effectively damped. Indications are independent of room temperature and of the heating effect of current passing through the windings, and the instruments are shielded from external magnetic influences.

The scales, which are 5 1/4 in. long, are uniform throughout their entire length, a characteristic of great importance. Each scale is hand-calibrated and is provided with a mirror over which the knife-edge pointer travels, and the pointers are equipped with a simple zero setting device.

Special model 310 wattmeters can be furnished for very low power factors, for instance, for the determination of the core losses in transformers, giving full-scale deflection for 20 per cent power factor; that is, the scale value in watts is 20 per cent of the volt-amperes applied. Temperature errors are very small and can be corrected by reference to the certificate that accompanies all Weston instruments. Scales are uniform and the instruments have otherwise the same general characteristics as the regular model.

While model 310 is a direct-

FIG. 1—OUTSIDE VIEW OF ELECTRODYNAMOMETER VOLTMETER

current or single-phase wattmeter, model 329 is a polyphase wattmeter; otherwise the above remarks agree likewise to model 329.

Model 341 is a direct-current or alternating-current portable electrodynamometer **voltmeter** and model 370 is a direct-current or alternating-current portable electrodynamometer **ammeter.** Their accuracy is the same as that of the wattmeter.

The scales of the voltmeter and ammeter are 5 1/4 in. long. Owing to the principle of operation these instruments cannot be made with scales that are uniform throughout their entire length, but the upper four-fifths portion of the scale is remarkably legible and uniform.

Undoubtedly the perfection of this new kind of instrument marks a distinct advance in the science and practice of electrical measurements.

New Riffling for Concentrating Tables

Progress in the art of concentration or ore-dressing has developed a number of new methods of riffling tables for special purposes. Several new types of riffling for Wilfley tables have been brought out by the Mine & Smelter Supply Company, Denver, Col., one of these, known as the No. 10 deck, being shown in two views in Figs. 1 and 2. The particular deck shown is installed in the metallurgical laboratory of the Colorado School of Mines, where it has been used successfully in making close separations with greater efficiency than could be obtained on the ordinary Wilfley deck.

In the No. 10 type of deck, three riffles extend parallel with, and the full length of, the lower edge of the table. Above these, the riffles which perform the main work of stratification are laid diagonally from the head-motion end toward the feed and wash-water boxes. These riffles terminate in a diagonal line, and every alternate one is extended a few inches at a smaller inclination toward the discharge end of the deck. These extensions also terminate in a diagonal line, except

FIG. 2—TYPICAL 150-LINE SCALE FOR ELECTRODYNAMOMETER VOLTMETER MODEL 341

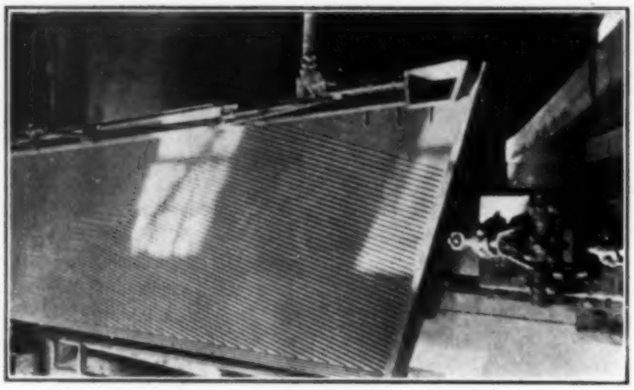

FIG. 1—NEW ARRANGEMENT OF RIFFLES

those near the lower side of the table, which extend to the discharge end. A feature essential to the proper distribution and stratification of the pulp is the three wooden cleats shown near the feed-box.

The improvement shown by the new deck over previous models is primarily an enormous increase in capacity, although greater efficiency has been found in separating minerals of nearly the same specific gravity. Under suitable conditions, where only a one-mineral separation is required, this table will handle up to five times as much unclassified-sand feed as earlier models. A relative increase in tonnage is obtainable with a classified feed for two-mineral separation. This increase in capacity is not gained at the sacrifice of quality in work done. The table is not a "rougher" in the usual sense of that term, for it delivers a finished product, combining the capacity of a roughing table with the efficiency of a finishing table.

A novelty in roughing tables is in use at Silverton, Col., where tables 12 ft. wide and 45 ft. long are handling a tremendous tonnage of old tailings that are being retreated. The feed is classified into coarse and fine grades, and both are fed to the same table—the coarse at the usual feed box and the fine near the discharge end.

Another development in rough concentration is the use of tables for the work formerly done by jigs in coal washing. The deck of a coal-washing table is 7 ft. by 16 ft., riffled horizontally over its entire surface. The capacity is from four to six tons per hour of feed broken to pass a ¼-in. ring. It is claimed that the table does more efficient work than the jig.

For concentration of classified-sand pulp on the ordinary Wilfley deck, some modifications of riffling have been introduced with good effect. With an unclassified feed every third or fourth riffle can be made higher than the others, producing a pond or lake in which stratification and separation can be made more effective. With this type of riffling the vortex usually formed when the pulp flows over each riffle is confined only to the high riffles, while the intervening area is undisturbed by these currents.

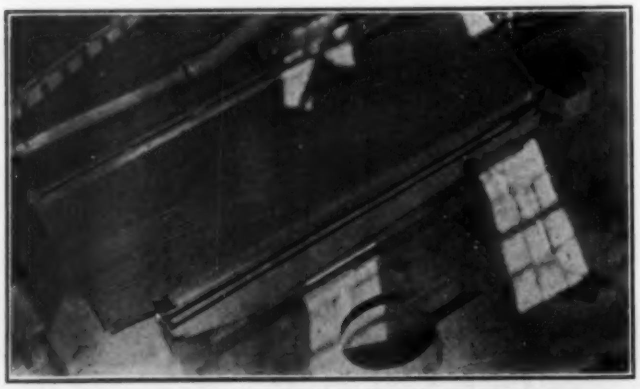

FIG. 2—ANOTHER VIEW OF NEW ARRANGEMENT OF RIFFLES

Personal

Mr. Charles W. Baker, formerly New York manager of sales of the Carnegie Steel Company, has been elected a director of the American Zinc, Lead & Smelting Co.

Mr. J. L. W. Birkinbine has been selected as consulting engineer of the Bureau of Mines and will prepare a monograph on the manufacture of iron and steel in this country.

Mr. G. Montague Butler is now Dean of the College of Mines and Engineering of the University of Arizona, Tucson, having resigned his position as professor of geology in the School of Mines, Corvallis, Oregon.

Mr. L. Collins of the Metal Coating Co. of America will lecture on November 18 before the Buffalo branch of the American Society of Mechanical Engineers on their process of coating metals (Schoop process) and on the following two days will demonstrate their process at the plant of the J. P. Devine Co. at Buffalo.

Mr. J. D. Connor, metallurgist of the South Australian Government, has recently arrived in this country to investigate the leaching of copper ores.

Mr. J. V. N. Dorr and **Mr. George E. Collins** will represent the Colorado Scientific Society in Washington on December 16 at a convention to be held under the auspices of the Mining and Metallurgical Society of America for the purpose of presenting to Congress the necessity of changes in the mining laws. Mr. Dorr is at present in Denver but expects to return to New York City about Thanksgiving time.

Dr. Francis C. Frary, formerly assistant professor of chemistry in the University of Minnesota, is now research chemist for the Oldbury Electrochemical Co., Niagara Falls, N. Y.

Mr. Edward Hamilton, formerly assistant superintendent of the Duquesne Works of the Carnegie Steel Co., is now general superintendent, succeeding **Mr. Homer D. Williams,** the recently elected president.

Mr. Henry D. Hibbard of Plainfield, N. J., has gone to Australia on a business trip.

Mr. H. O. Howard of San Francisco is in Nevada making an investigation of the districts around Lovelock.

Mr. Wasata Kondo and **Mr. M. Yamashita** of Japan have recently come to this country to make a study of metallurgical practice.

Mr. James F. McCarthy has been appointed manager of the National Copper Mining Co., Mullan, Idaho.

Mr. Edward McFarlan has been placed in charge of the New York office of the Metals Coating Co. of America, recently opened at 30 Church Street. This company owns the patents for the Schoop spray process.

Mr. F. E. Marcy of the Mine & Smelter Supply Co., Denver, Colo., has resigned to go into business of his own.

Mr. J. J. Rockwell has rejoined the staff of the McGraw Publishing Company, publisher of "Metallurgical and Chemical Engineering," "Electrical World," "Electric Railway Journal," and "Engineering Record," as advertising counselor.

Mr. Richard K. Meade of Baltimore, Md., has been retained by the D. M. Bare Paper Company of Roaring Springs, Pa., to prepare plans and to superintend the construction of a lime recovery plant for converting the lime waste or sludge now discarded into lime of the highest quality. The kiln will be a giant revolv-

ing cylinder 6 ft. in diameter and 100 ft. long, and the lime as it falls red hot from this kiln will be automatically cooled and conveyed to the lime house. Novel features will be introduced in the heating of the kiln and all of the machinery will be motor-driven.

Mr. C. A. Menk of the Homestead Works of the Carnegie Steel Co., was elected second vice-president of the Association of Iron and Steel Electrical Engineers at its recent Detroit convention.

Mr. Thos. M. Skinner, Jr., has completed his work pertaining to the handling of the alkali waters of Owens Lake, Cal., and has returned to Denver, Colo.

Mr. Acheson Smith, general manager of the International Acheson Graphite Company, has been nominated as one of the commissioners for the proposed commission government of Niagara Falls, N. Y. Mr. Smith has the best wishes of his many friends in the electrochemical and electrometallurgical industries of this country for his election on Nov. 2.

Mr. C. W. Whitley of the American Smelting & Refining Co., was elected chairman of the Utah Section of the A. I. M. E. at their first annual meeting on Oct. 4, in Salt Lake City.

Digest of Electrochemical U. S. Patents

PRIOR TO 1903

Arranged according to subject-matter and in chronological order.

Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.

Aqueous Bath Apparatus

(Continued)

151,892, June 9, 1874, Henry Lovejoy, Henry W. Lovejoy and James H. Ferguson of Brooklyn and Michael J. Creegan of New York, N. Y.

Relates to an apparatus for electroplating, consisting of a hanger or hook for suspending articles to be plated, such as molds for electrotypes, etc. The hanger consists of a metallic bar, having a ring at the top for handling, and a hook by which the bar is suspended from the conducting rod. The bottom of the bar is divided so as to form two arms extending laterally a short distance on both sides, and turning toward the front, their ends forming bearers for the mold. Between the arms is secured insulating material, which supports a hook by which the mold is suspended. (This patent was reissued under No. 8726, dated May 27, 1879.)

158,972, Jan. 19, 1875, Henry E. Osborn of Wallingford, Conn.

Relates to racks for electroplating, and consists in a thin, flat bar, suspended horizontally by hooks hanging from a conductor above the bath, the flat bar being slotted longitudinally, the slot being notched on each side by rounded saw-tooth notches, the notches on one side being opposite those on the other. Spoon handlers, and the like, are inserted flat-wire in the slot, and then turned at right angles and placed in the notches, the spoon being thereby suspended and electrically connected for plating. They may be arranged to support a dozen or more spoons at one time.

169,878, Nov. 9, 1875, Stephen W. Wood of Cornwall, N. Y.

Relates to the manufacture of metal tubing by electrodeposition, and the removal of the tubing from the mandrel upon which it was deposited. A metallic mandrel having a polished dense surface is used as the cathode, and metal deposited thereon to a desired thickness. The coated mandrel is then subjected to a rolling, burnishing, or drawing process to loosen the deposit, the patent illustrating a system of rollers which are said to answer the purpose. The rolling action expands the deposited metal which thereby separates from the mandrel. After its removal the tube may be drawn to any suitable size.

192,112, June 19, 1877, William B. Closson of Boston, Mass.

Relates to the production of molds for the duplication of medals, etc., from an original. The medal desired to be reproduced is surrounded with two split frames of thin metal, having smooth surfaces which are pressed tightly together. Holes are previously made in one piece, and corresponding indentations in the other piece of metal registering with the holes. The combined metal sheets and medal are provided with wax masses on each side at one point to form sprue holes or openings for molten metal. The medal and the wax are covered with graphite, and the assembled form electroplated. After a sufficient deposit has been formed, it is removed, the edges around the metal sheets filed off and the two sheets of metal separated, each supporting one-half of the deposit, and the medal removed. The two parts of the mold may be readily assembled, the indentations registering with the holes. The sides may be reinforced by molten lead, plaster of paris, etc.

195,443, Sept. 25, 1877, William B. Closson of Boston, Mass.

Relates to a method of forming electroplated molds for casting articles of statuary, etc. The object to be duplicated is coated with wax, a portion is then uncovered, leaving perpendicular walls on the wax coating. The article and walls of the wax are then coated with graphite, and then electroplated. Then a second portion of the mold is uncovered, leaving perpendicular sides on the wax remaining, and using one wall of the prior deposit as a surface for a new wall. This is then coated with graphite and electroplated. The entire object to be reproduced is treated in this manner, care being taken that the several portions uncovered and on which deposits are made shall form readily removable mold sections. These several sections, when completed, are to be assembled to form a complete mold.

197,408, Nov. 20, 1877, Julius W. Rogers of West Meriden, Conn.

Relates to frames for holding articles to be electroplated. It consists of an expansible grid, adjustable so as to hold articles of different sizes, the grid consisting of a plurality of parallel rods below which are attached flat springs, a spring on one rod pressing against a spring on the next rod. Articles to be plated, such as screws and the like, are pressed between the springs, the head of the screw remaining exposed and may be immersed in the solution without immersing the springs. For large articles the frame is expanded, giving a wider space between the springs.

Reissue 8726, May 27, 1879, Henry Lovejoy, Henry W. Lovejoy and James H. Ferguson of Brooklyn and Michael J. Creegan of New York, N. Y.

This patent contains a more complete description of the hanger described in the original patent (No. 151,892).

218,473, Aug. 12, 1879, Robert Barrie of Chelsea, Mass.

Relates to making duplicates of statuary, etc., and consists in first making a mold, preferably sectional, by coating the object with wax, exposing a portion and leaving deep perpendicular sides on the wax edges, coating the wax and object with graphite, and electroplating, the perpendicular sides of the wax forming flanges for the sections of the mold. After the entire object has been treated in this manner the flanges are drilled for

the reception of bolts to aid in reassembling, and the several sections then removed from the object, and after reassembling, is dusted with graphite inside and electroplated with any metal of which the duplicate is desired. When completed, the mold sections are removed, and the article finished by buffing, etc., or otherwise.

224,478, Feb. 10, 1880, Julius W. Rogers of West Meriden, Conn.

Relates to frames for supporting articles to be electroplated, the frame consisting of a suitable holder such as a drilled metal ring or rectangle of any shape, with arms for suspending the same, the outer surfaces of the ring and arms being covered with a glazing of vitrified material such as glass, etc., which prevents the deposition of metal on the ring.

Book Reviews

The Mineral Industry. Its Statistics, Technology and Trade during 1914. Edited by **G. A. Roush**, M.S. Large octavo, XVIII + 998 pages. Price $10. New York: McGraw-Hill Book Company, Inc.

At the present time each successive volume of this annual has a more difficult task in living up to the reputation and standard of its predecessors. Yet the present editor seems equal to the task, and the present volume is the best which has appeared in recent years. Besides the contributions from the "old standbys," which need no further comment, we must record the addition of many familiar names to the list of contributors. Heading such a list is an introductory article by the director of the U. S. Geological Survey, Mr. George Otis Smith, which discusses the dislocation and readjustment of various mineral industries resulting from the present world war. Dr. David T. Day writes authoritatively on his specialty, petroleum and natural gas; Prof. James F. Kemp on platinum, Dr. F. G. Cottrell and Linn Bradley on the smoke problem, Clifford Richardson on asphalt, Kenneth Seaver on refractory materials, and so the list could be extended, including many prominent specialists in the mining, metallurgical, and chemical fields. It is a symphony of experts whose work it were presumptuous to criticise rashly, yet we must express regret that Professor Richards is unable to furnish anything more reliable than estimates (or perhaps they are "guesstimates") of the annual production of aluminium, and perhaps there are a few other discordant notes in the symphony. But criticism is really captious, since the strong points of the work so utterly outnumber its minor shortcomings. It deserves, as a whole, the heartiest recommendation to all who wish to keep abreast of the latest developments in the mining and metallurgical industries.

Abridged Scientific Publications from the Research Laboratory of the Eastman Kodak Company, 1913-1914. 76 pages, illustrated. Rochester, N. Y.: Eastman Kodak Company.

"Research work in any field is of many different grades, ranging from the investigation of the fundamental problems of a science to the working out of the purely practical problems in production. Research problems show a tendency to fall into three chief classes: (1) Problems of purely scientific interest; (2) problems in applied science, largely the determination of exact data and the working out of methods of testing, (3) engineering problems in the application of scientific data and laws and routine testing. Industrial research laboratories usually cover the first two classes of research in any given field, the third class is taken care of by individual departments of the works.

"The Research Laboratory of the Eastman Kodak Company is organized in accordance with these principles. Some work is being carried on along lines leading to results of no apparent practical importance whatever. On the other hand, practical problems of a very recondite nature are referred to it at times by the manufacturing department. But the great bulk of its work lies in the middle ground of the investigation of the properties of materials, including the determination of precise physical and chemical data, a large proportion of the investigation being initiated by the men within the laboratory.

"There are three chief departments of the laboratory: Chemistry, physics and photography, about equally balanced as regards number of men and space occupied. The chemical department contains subdivisions dealing chiefly with problems in inorganic, organic and colloid chemistry. The work of the physics department is chiefly along the lines of photometry, spectroscopy, lens optics, visual and photographic optics, colorimetry, and allied subjects. Photographic research covers photographic chemistry and the various photographic processes. Many problems are, of course, investigated by two or more departments in co-operation. Technical research, routine tests of product, the investigation of works troubles and the development of new works processes are fully provided for outside the Research Laboratory.

"The Laboratory was organized in 1912, and work was in full swing in the new building early in 1913. The more important scientific results of general interest that have been obtained have been published in various scientific journals. Some of these are not available to many who wish these results and hence an abstract journal is being published which shall contain all of the more important results of each paper. This number contains abstracts of all scientific papers published during 1913 and 1914."

There are twenty-two papers in number, namely: The Absorption of Light in Heterogeneous Media, by P. G. Nutting; The Physical Chemistry of Photographic Development, by C. E. K. Mees; The Sensitometry of Process Plates, by C. E. K. Mees; Calculation of Exposure, by C. E. K. Mees; The Triple Projection Process of Color Photography, by C. E. K. Mees; Brightness and Contrast in Optical Images, by P. G. Nutting; The Correction of Process Lenses for Light in the Extreme Violet, by P. G. Nutting; The Distribution of the Silver Grain in the Developed Image, by Orin Tugman; A New Standard Light Source, by L. A. Jones; Color Analyses of Two Component Mixtures, by L. A. Jones; Photographic Resolving Power, by P. G. Nutting; Light Filters for Use in Photometry, by C. E. K. Mees; The Color of Illuminants, by L. A. Jones; Transmission and Reflection Photometer for Small Areas, by P. G. Nutting and L. A. Jones; Reflecting Power Standards, by P. G. Nutting, L. A. Jones and F. A. Elliott; Axial Chromatic Aberration of the Human Eye, by P. G. Nutting; The Visibility of Radiation, by P. G. Nutting; Mixed Specular and Diffuse Reflection, by P. G. Nutting; The Sensitometry of Photographic Papers, by P. G. Nutting, L. A. Jones and C. E. K. Mees, and The Physics of the Photographic Process, by C. E. K. Mees.

Dr. Mees and his co-workers must be sincerely congratulated on the fine showing of this first volume. The papers were originally published in quite a number of different independent journals and are here collected somewhat abstracted. This is the correct practice if the object of papers is dissemination of knowledge rather than glorification of the laboratory or bureau from which they originated. There are some State and Government bureaus, and even others, that have still to learn this simple obvious truth.